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# EFFECTS OF METHYLANDROSTENEDIOL, METHYLTESTOSTERONE AND THYROPROTEIN ON GROWTH AND CARCASS CHARACTERISTICS OF SWINE [1]

M. D. Whiteker, H. Brown,[2] C. E. Barnhart, J. D. Kemp and W. Y. Varney
*University of Kentucky, Lexington*

MANY workers (Sleeth *et al.*, 1953; Bratzler *et al.*, 1954; Perry *et al.*, 1954; Beeson *et al.*, 1955; Perry *et al.*, 1954; Noland *et al.*, 1956) have reported that testosterone when fed or implanted did not improve the growth rate or feed efficiency of growing-finishing pigs. Most of these workers observed improved carcass quality as a result of feeding testosterone, but noted some undesirable side effects. Thyroprotein fed to growing-finishing pigs has been shown to increase growth rate and improve feed efficiency (Reineke *et al.*, 1946; Beeson *et al.*, 1947; Perry *et al.*, 1950). On the other hand, Braude (1947), Muhrer *et al.* (1947), and Vander Noot *et al.* (1948) reported either no growth response or a depression in growth from thyroprotein.

Gordon (1951) found that methylandrostenediol was a protein-anabolic steroid with little genital activity and that it was a promising agent with metabolic actions similar to those of methyltestosterone. In studies with human female subjects, methylandrostenediol proved effective for weight gain. Korner *et al.* (1955) conducted trials with male and female rats to determine the effects of methylandrostenediol on body weight and carcass composition. The treated rats gained significantly faster and had carcasses that produced more protein and water and less fat.

This paper summarizes three experiments conducted to determine the effects of feeding methyltestosterone, methylandrostenediol and thyroprotein to growing-finishing pigs.

## Experimental Procedure

*Feeding Trials.* In Experiments 1 and 2, 24 Duroc pigs were allotted to two replications of three ration treatments. The ration treatments were as follows: (1) Basal ration, (2) basal plus methylandrostenediol at a level to provide each pig 10 mg. per day, and (3) basal plus methylandrostenediol to provide each pig 20 mg. per day. The amounts of methylandrostenediol were adjusted according to feed intake of the pigs every two weeks. The pigs were self-fed on a concrete floor; they had access to an automatic waterer. Each pig was removed from experiment when it reached a live

[1] This project was partially financed by a grant-in-aid provided by Mallinckrodt Chemical Co., St. Louis, Mo.
[2] Present address: Animal Husbandry Department, Iowa State College, Ames, Iowa.

weight of 200 lb. and was slaughtered at the meat laboratory. The pigs were fed 16% protein rations until they reached 75 lb., 14% protein rations from 75 to 125 lb., and 12% protein rations thereafter. The basal rations are presented in table 1.

In Experiment 3, 48 Hampshire pigs, averaging 38 lb. were allotted to two replications of six ration treatments. The ration treatments were as follows: (1) Basal (table 1), (2) basal plus methylandrostenediol at a

TABLE 1. PERCENTAGE COMPOSITION OF THE BASAL RATIONS

| Ingredients | Ration protein | | |
|---|---|---|---|
| | 12% | 14% | 16% |
| Ground yellow corn | 86.85 | 80.85 | 75.35 |
| Solvent soybean oil meal, 44% | 10.00 | 16.00 | 21.50 |
| Steamed bone meal | 1.25 | 1.25 | 1.25 |
| Ground limestone | .75 | .75 | .75 |
| Salt (white) | .50 | .50 | .50 |
| Trace mineral mixture[a] | .30 | .30 | .30 |
| Vitamin supplement[b] | .20 | .20 | .20 |
| Vitamin A and D supplement[c] | .05 | .05 | .05 |
| Vitamin $B_{12}$ supplement[d] | .05 | .05 | .05 |
| Antibiotic[e] | .05 | .05 | .05 |

[a] One pound of the trace mineral mixture contained: manganese, 55.388 gm.; iron, 43:584 gm.; calcium, 34.050 gm.; copper, 3.3142 gm.; zinc, 3.0418 gm.; iodine, 1.7252 gm.; cobalt 1.1804 gm.

[b] One pound of the vitamin supplement supplied not less than 2 gm. riboflavin, 4 gm. pantothenic acid, 9000 mg. niacin, 10 gm. choline chloride, and 60 mg. of folic acid.

[c] One pound of the vitamin A and D supplement contained not less than 4,450,000 USP units of vitamin A and not less than 567,500 USP units of vitamin $D_2$.

[d] The vitamin $B_{12}$ supplement contained 10 mg. of vitamin $B_{12}$ per pound.

[e] The antibiotic furnished 10 gm. of chlortetracycline hydrochloride per pound.

level to provide 20 mg. per head daily, (3) basal plus methylandrostenediol to provide 40 mg. per head daily, (4) basal plus methyltestosterone to provide 20 mg. per head daily, (5) same as (2) plus 10 mg. of thyroprotein per pound of feed, and (6) basal plus 10 mg. of thyroprotein per pound of feed.

The same procedures were followed in this experiment as described for Experiments 1 and 2.

*Carcass Measurements.* In Experiment 1 each carcass was measured and cut after 48 hours of chill. Depth of backfat was measured at the first and last rib, and the last lumbar vertebra. Length of carcass, depth of hamfat, area of the cross section of the loin at the 10th rib and area of the cross section of the ham 2 inches vertical to and parallel to the long axis of the aitch bone were also recorded. A taste-panel was used to determine whether there was any adverse taste or odor due to methylandrostenediol. Loin roasts from two barrows and two gilts from each ration treatment were cooked and served the panel members. Standard laboratory methods were

employed to determine the percent protein, fat and moisture of the lean portion of the loins.

In Experiments 2 and 3, in addition to obtaining the above carcass data, the carcasses were cut into the retail carcass cuts and the percent lean and fat cuts calculated on the basis of carcass weight. Live backfat probes were made on all the pigs on Experiment 3 when averaging 125 lb. live weight. A taste-panel was used in Experiment 3 but not in Experiment 2 to determine whether there was any adverse odor or flavor in the loins.

## Results and Discussion

*Experiment 1.* The feeding of methylandrostenediol at levels of 10 or 20 mg. per pig daily failed to improve average daily gain, feed required per pound of gain or carcass quality, significantly (table 2). There was a

TABLE 2. EFFECTS OF METHYLANDROSTENEDIOL ON GROWTH AND CARCASS CHARACTERISTICS OF GROWING-FINISHING PIGS (EXPERIMENT 1)

| Item | Ration treatment | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Number of pigs | 8 | 8 | 8 |
| Av. daily gain, lb. | 1.73 | 1.73 | 1.69 |
| Feed per 100-lb. gain, lb. | 336.00 | 336.00 | 349.00 |
| Av. depth of backfat, in. | 1.62 | 1.61 | 1.54 |
| Av. depth of hamfat, in. | 1.34 | 1.38 | 1.30 |
| Av. length of carcass, in. | 28.10 | 28.30 | 28.30 |
| Av. area of loin eye, sq. in. | 3.69 | 3.82 | 3.92 |
| Av. area of ham, sq. in. | 37.73 | 37.86 | 38.48 |
| Av. liver weight, lb. | 2.79 | 2.95 | 2.96 |
| Av. viscera weight, lb. | 7.72 | 7.74 | 7.32 |
| Av. dressing percentage[a] | 81.10 | 80.80 | 80.80 |

[a] Shipper style.

tendency toward more leanness as the level of the additive was increased. Odor and taste were not affected. Methylandrostenediol at both levels appeared to increase the nitrogen content of loin samples but differences were not significant (table 3).

*Experiment 2.* Methylandrostenediol failed to improve rate of gain or feed efficiency. In fact, pigs fed this androgen-like compound consumed slightly more feed per unit of gain than pigs fed the control ration. There was no significant difference between the carcass measurements of the pigs fed the three different rations (table 4). In this experiment, methylandrostenediol appeared to decrease the protein content of loin samples, as compared to control samples; however, differences were not significant (table 3).

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| Ground limestone | .75 | .75 | .75 |
| Salt (white) | .50 | .50 | .50 |
| Trace mineral mixture[a] | .30 | .30 | .30 |
| Vitamin supplement[b] | .20 | .20 | .20 |
| Vitamin A and D supplement[c] | .05 | .05 | .05 |
| Vitamin $B_{12}$ supplement[d] | .05 | .05 | .05 |
| Antibiotic[e] | .05 | .05 | .05 |

[a] One pound of the trace mineral mixture contained: manganese, 55.388 gm.; iron, 43:584 gm.; calcium, 34.050 gm.; copper, 3.3142 gm.; zinc, 3.0418 gm.; iodine, 1.7252 gm.; cobalt 1.1804 gm.

[b] One pound of the vitamin supplement supplied not less than 2 gm. riboflavin, 4 gm. pantothenic acid, 9000 mg. niacin, 10 gm. choline chloride, and 60 mg. of folic acid.

[c] One pound of the vitamin A and D supplement contained not less than 4,450,000 USP units of vitamin A and not less than 567,500 USP units of vitamin $D_2$.

[d] The vitamin $B_{12}$ supplement contained 10 mg. of vitamin $B_{12}$ per pound.

[e] The antibiotic furnished 10 gm. of chlortetracycline hydrochloride per pound.

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employed to determine the percent protein, fat and moisture of the lean portion of the loins.

In Experiments 2 and 3, in addition to obtaining the above carcass data, the carcasses were cut into the retail carcass cuts and the percent lean and fat cuts calculated on the basis of carcass weight. Live backfat probes were made on all the pigs on Experiment 3 when averaging 125 lb. live weight. A taste-panel was used in Experiment 3 but not in Experiment 2 to determine whether there was any adverse odor or flavor in the loins.

## Results and Discussion

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| Item | Ration treatment | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Number of pigs | 8 | 8 | 8 |
| Av. daily gain, lb. | 1.73 | 1.73 | 1.69 |
| Feed per 100-lb. gain, lb. | 336.00 | 336.00 | 349.00 |
| Av. depth of backfat, in. | 1.62 | 1.61 | 1.54 |
| Av. depth of hamfat, in. | 1.34 | 1.38 | 1.30 |
| Av. length of carcass, in. | 28.10 | 28.30 | 28.30 |
| Av. area of loin eye, sq. in. | 3.69 | 3.82 | 3.92 |
| Av. area of ham, sq. in. | 37.73 | 37.86 | 38.48 |
| Av. liver weight, lb. | 2.79 | 2.95 | 2.96 |
| Av. viscera weight, lb. | 7.72 | 7.74 | 7.32 |
| Av. dressing percentage[a] | 81.10 | 80.80 | 80.80 |

[a] Shipper style.

tendency toward more leanness as the level of the additive was increased. Odor and taste were not affected. Methylandrostenediol at both levels appeared to increase the nitrogen content of loin samples but differences were not significant (table 3).

*Experiment 2.* Methylandrostenediol failed to improve rate of gain or feed efficiency. In fact, pigs fed this androgen-like compound consumed slightly more feed per unit of gain than pigs fed the control ration. There was no significant difference between the carcass measurements of the pigs fed the three different rations (table 4). In this experiment, methylandrostenediol appeared to decrease the protein content of loin samples, as compared to control samples; however, differences were not significant (table 3).

TABLE 3. THE EFFECT OF METHYLANDROSTENEDIOL ON PROTEIN CONTENT OF THE LOIN OF GROWING-FINISHING PIGS [a]

| Ration treatment | Protein, gm. per kilogram of loin |
|---|---|
| Experiment 1 | |
| 1 | 145 |
| 2 | 150 |
| 3 | 151 |
| Experiment 2 | |
| 1 | 154 |
| 2 | 145 |
| 3 | 153 |
| Experiment 3 | |
| 1 | 154 |
| 2 | 149 |
| 3 | 149 |
| 4 | 150 |
| 5 | 143 |
| 6 | 153 |

[a] The protein content is based on fat-free, moisture-free loin samples.

*Experiment 3.* Average daily gain was not significantly affected by methylandrostenediol, thyroprotein or a combination of the two. Live backfat probes made when the pigs weighed 125 lb. indicated that the pigs fed methylandrostenediol and methyltestosterone had less backfat than the

TABLE 4. THE EFFECT OF METHYLANDROSTENEDIOL ON GROWTH AND CARCASS CHARACTERISTICS OF GROWING-FATTENING DUROC PIGS (EXPERIMENT 2)

| Item | Ration treatment | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Number of pigs | 8 | 8 | 7[a] |
| Av. initial weight, lb. | 49.00 | 49.00 | 49.00 |
| Av. daily gain, lb. | 1.63 | 1.65 | 1.64 |
| Feed per 100 lb. gain, lb. | 332.00 | 356.00 | 341.00 |
| Av. feed consumed per day, lb. | 5.37 | 5.86 | 5.63 |
| Av. length of carcass, in. | 28.46 | 27.13 | 27.92 |
| Av. area loin eye 10th rib, sq. in. | 3.69 | 3.11 | 3.37 |
| Lean cuts, percent of carcass | 56.68 | 55.19 | 54.97 |
| Fatcuts, percent of carcass | 21.47 | 23.29 | 22.94 |
| Av. weight of both hams, lb. | 30.79 | 30.45 | 30.79 |
| Av. weight of both Boston butts, lb. | 9.83 | 9.15 | 8.75 |
| Av. weight of both picnics, lb. | 14.01 | 14.25 | 14.23 |
| Av. dressing percent[b] | 71.00 | 70.90 | 70.60 |
| Av. depth of backfat, in. | 1.51 | 1.61 | 1.61 |

[a] One pig died.
[b] Packer style.

TABLE 5. THE EFFECT OF METHYLANDROSTENEDIOL, METHYLESTOSTERONE AND THYROPROTEIN ON GROWTH AND CARCASS CHARACTERISTICS OF GROWING-FATTENING HAMPSHIRE PIGS

| Item | Ration treatment | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Number of pigs | 8 | 7[a] | 8 | 8 | 8 | 8 |
| Av. initial wt., lb. | 38.00 | 38.00 | 38.00 | 38.00 | 38.00 | 38.00 |
| Av. daily gain, lb. | 1.49 | 1.50 | 1.52 | 1.44 | 1.48 | 1.51 |
| Feed per 100-lb gain, lb. | 344.00 | 355.00 | 345.00 | 356.00 | 334.00 | 349.00 |
| Av. feed consumed per day, lb. | 5.11 | 5.38 | 5.22 | 5.09 | 5.24 | 5.00 |
| Av. live backfat probe at 125-lb., in. | 1.11 | 1.01 | 1.01 | 1.03 | 1.31 | 1.26 |
| Av. length of carcass, in. | 29.26 | 28.60 | 28.90 | 29.18 | 28.99 | 28.48 |
| Av. loin eye area at 10th rib, sq. in. | 3.70 | 3.62 | 3.94 | 4.12 | 4.07 | 3.88 |
| Lean cuts, percent of carcass | 56.26 | 55.84 | 57.93 | 59.06 | 58.89 | 56.19 |
| Fat cuts, percent of carcass | 20.44 | 21.11 | 19.35 | 18.17 | 19.13 | 20.36 |
| Av. weight of both hams, lb. | 30.27 | 30.25 | 30.43 | 31.10 | 31.36 | 31.09 |
| Av. weight of both Boston butts, lb. | 7.83 | 8.65 | 8.92 | 8.47 | 8.96 | 8.68 |
| Av. weight of both loins, lb. | 22.78 | 23.22 | 22.97 | 24.03 | 23.22 | 23.18 |
| Av. weight of both picnics, lb. | 12.90 | 13.06 | 12.90 | 12.84 | 13.33 | 12.65 |
| Av. backfat, in. | 1.42 | 1.46 | 1.28 | 1.28 | 1.31 | 1.46 |

[a] One pig removed from trial because of prolapsed rectum.

TABLE 6. ANALYSIS OF VARIANCE (EXPERIMENT 3)

| Source of variance | Degree of freedom | Sum of squares | Mean square |
|---|---|---|---|
| | Live backfat probe | | |
| Treatment | 5 | 0.74 | 0.14* |
| 1 vs. 2, 3 and 4 | 1 | .18 | .18 |
| 2, 3 and 4 vs. 5 and 6 | 1 | .72 | .72** |
| 1 vs. 5 and 6 | 1 | .06 | .06 |
| 5 vs. 6 | 1 | .01 | .01 |
| Sex | 1 | .09 | .09 |
| Sex vs. treatment | 5 | .42 | .08 |
| Error | 35 | 2.10 | .06 |
| Total | 46 | 3.35 | .... |
| | Percent lean cuts | | |
| Treatment | 5 | 80.77 | 16.15* |
| 1 vs. 2 and 3 | 1 | 3.56 | 3.56 |
| 1 vs. 4 | 1 | 31.08 | 31.08* |
| 1 vs. 6 | 1 | 0.43 | 0.43 |
| 5 vs. 2 | 1 | 30.14 | 30.14* |
| 6 vs. 5 | 1 | 37.08 | 37.08* |
| Sex | 1 | 12.83 | 12.83 |
| Sex vs. treatment | 5 | 17.23 | 3.45 |
| Error | 35 | 196.49 | 4.61 |
| Total | 46 | ..... | ..... |

* Significant at 5% level.
** Significant at 1% level.

TABLE 3. THE EFFECT OF METHYLANDROSTENEDIOL ON PROTEIN CONTENT OF THE LOIN OF GROWING-FINISHING PIGS [a]

| Ration treatment | Protein, gm. per kilogram of loin |
|---|---|
| Experiment 1 | |
| 1 | 145 |
| 2 | 150 |
| 3 | 151 |
| Experiment 2 | |
| 1 | 154 |
| 2 | 145 |
| 3 | 153 |
| Experiment 3 | |
| 1 | 154 |
| 2 | 149 |
| 3 | 149 |
| 4 | 150 |
| 5 | 143 |
| 6 | 153 |

[a] The protein content is based on fat-free, moisture-free loin samples.

*Experiment 3.* Average daily gain was not significantly affected by methylandrostenediol, thyroprotein or a combination of the two. Live backfat probes made when the pigs weighed 125 lb. indicated that the pigs fed methylandrostenediol and methyltestosterone had less backfat than the

TABLE 4. THE EFFECT OF METHYLANDROSTENEDIOL ON GROWTH AND CARCASS CHARACTERISTICS OF GROWING-FATTENING DUROC PIGS (EXPERIMENT 2)

| Item | Ration treatment | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Number of pigs | 8 | 8 | 7[a] |
| Av. initial weight, lb. | 49.00 | 49.00 | 49.00 |
| Av. daily gain, lb. | 1.63 | 1.65 | 1.64 |
| Feed per 100 lb. gain, lb. | 332.00 | 356.00 | 341.00 |
| Av. feed consumed per day, lb. | 5.37 | 5.86 | 5.63 |
| Av. length of carcass, in. | 28.46 | 27.13 | 27.92 |
| Av. area loin eye 10th rib, sq. in. | 3.69 | 3.11 | 3.37 |
| Lean cuts, percent of carcass | 56.68 | 55.19 | 54.97 |
| Fatcuts, percent of carcass | 21.47 | 23.29 | 22.94 |
| Av. weight of both hams, lb. | 30.79 | 30.45 | 30.79 |
| Av. weight of both Boston butts, lb. | 9.83 | 9.15 | 8.75 |
| Av. weight of both picnics, lb. | 14.01 | 14.25 | 14.23 |
| Av. dressing percent[b] | 71.00 | 70.90 | 70.60 |
| Av. depth of backfat, in. | 1.51 | 1.61 | 1.61 |

[a] One pig died.
[b] Packer style.

TABLE 5. THE EFFECT OF METHYLANDROSTENEDIOL, METHYLESTOSTERONE AND THYROPROTEIN ON GROWTH AND CARCASS CHARACTERISTICS OF GROWING-FATTENING HAMPSHIRE PIGS

| Item | Ration treatment | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Number of pigs | 8 | 7[a] | 8 | 8 | 8 | 8 |
| Av. initial wt., lb. | 38.00 | 38.00 | 38.00 | 38.00 | 38.00 | 38.00 |
| Av. daily gain, lb. | 1.49 | 1.50 | 1.52 | 1.44 | 1.48 | 1.51 |
| Feed per 100-lb gain, lb. | 344.00 | 355.00 | 345.00 | 356.00 | 334.00 | 349.00 |
| Av. feed consumed per day, lb. | 5.11 | 5.38 | 5.22 | 5.09 | 5.24 | 5.00 |
| Av. live backfat probe at 125-lb., in. | 1.11 | 1.01 | 1.01 | 1.03 | 1.31 | 1.26 |
| Av. length of carcass, in. | 29.26 | 28.60 | 28.90 | 29.18 | 28.99 | 28.48 |
| Av. loin eye area at 10th rib, sq. in. | 3.70 | 3.62 | 3.94 | 4.12 | 4.07 | 3.88 |
| Lean cuts, percent of carcass | 56.26 | 55.84 | 57.93 | 59.06 | 58.89 | 56.19 |
| Fat cuts, percent of carcass | 20.44 | 21.11 | 19.35 | 18.17 | 19.13 | 20.36 |
| Av. weight of both hams, lb. | 30.27 | 30.25 | 30.43 | 31.10 | 31.36 | 31.09 |
| Av. weight of both Boston butts, lb. | 7.83 | 8.65 | 8.92 | 8.47 | 8.96 | 8.68 |
| Av. weight of both loins, lb. | 22.78 | 23.22 | 22.97 | 24.03 | 23.22 | 23.18 |
| Av. weight of both picnics, lb. | 12.90 | 13.06 | 12.90 | 12.84 | 13.33 | 12.65 |
| Av. backfat, in. | 1.42 | 1.46 | 1.28 | 1.28 | 1.31 | 1.46 |

[a] One pig removed from trial because of prolapsed rectum.

TABLE 6. ANALYSIS OF VARIANCE (EXPERIMENT 3)

| Source of variance | Degree of freedom | Sum of squares | Mean square |
|---|---|---|---|
| | Live backfat probe | | |
| Treatment | 5 | 0.74 | 0.14* |
| 1 vs. 2, 3 and 4 | 1 | .18 | .18 |
| 2, 3 and 4 vs. 5 and 6 | 1 | .72 | .72** |
| 1 vs. 5 and 6 | 1 | .06 | .06 |
| 5 vs. 6 | 1 | .01 | .01 |
| Sex | 1 | .09 | .09 |
| Sex vs. treatment | 5 | .42 | .08 |
| Error | 35 | 2.10 | .06 |
| Total | 46 | 3.35 | .... |
| | Percent lean cuts | | |
| Treatment | 5 | 80.77 | 16.15* |
| 1 vs. 2 and 3 | 1 | 3.56 | 3.56 |
| 1 vs. 4 | 1 | 31.08 | 31.08* |
| 1 vs. 6 | 1 | 0.43 | 0.43 |
| 5 vs. 2 | 1 | 30.14 | 30.14* |
| 6 vs. 5 | 1 | 37.08 | 37.08* |
| Sex | 1 | 12.83 | 12.83 |
| Sex vs. treatment | 5 | 17.23 | 3.45 |
| Error | 35 | 196.49 | 4.61 |
| Total | 46 | ..... | ..... |

* Significant at 5% level.
** Significant at 1% level.

controls; and those fed thyroprotein and thyroprotein plus methylandrostenediol had more backfat than the controls. The live backfat measurement was significantly less for pigs receiving 20 mg. or 40 mg. of methylandrostenediol or methyltestosterone than for those fed a combination of thyroprotein and methylandrostenediol or thyroprotein alone. Methyltestosterone produced carcasses that had a significantly higher (5% level) percent of lean cuts than the pigs receiving the basal ration. A combination of thyroprotein and methylandrostenediol resulted in a significantly higher (5% level) percent of lean than either of the additives alone. A summary of the rate of gain, feed efficiency and carcass data is presented in table 5.

The taste preference panel found no adverse flavor caused by any of the additives.

Protein content of the loin was not increased by any of the additives but tended to decrease and was 7% lower for treatment 5 as compared to the controls (table 3).

Both barrows and gilts receiving methyltestosterone showed masculine behavior and characteristics.

## Summary

In three trials involving 96 growing-finishing pigs fed methylandrostenediol, methyltestosterone, thyroproprotein, and a combination of the latter two, rate of gain was not significantly affected by any of these additives. The combination of methylandrostenediol and thyroprotein produced significantly more lean than either of the two fed alone. The pigs fed methyltestosterone produced carcasses that had a significantly higher percent of lean than the pigs fed the basal ration.

None of the ration treatments produced meat that possessed an adverse taste. Protein content was not significantly affected by any of the ration treatments. Masculine behavior and characteristics were noted among the animals receiving methyltestosterone.

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# THE VALUE OF SUPPLEMENTAL TRACE MINERALS IN CATTLE FATTENING RATIONS[1]

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KLOSTERMAN *et al.* (1953) reported that for fattening steers a ration composed of ground ear corn, soybean meal and poor quality timothy hay was deficient in trace minerals. The cattle gained faster and more efficiently when alfalfa ash or a trace mineral mixture furnishing iron, copper, cobalt, manganese and zinc was included in the ration. Bentley *et al.* (1954) using a somewhat similar ration obtained increased gains when the same mineral mixture or alfalfa ash was included in the ration. They indicated that cobalt was primarily responsible for the better performance of the animals. Klosterman *et al.* (1956) confirmed their results with trace minerals and in addition found that molasses would give similar benefits.

According to Nelson *et al.* (1957) trace minerals added to a pelleted supplement containing urea, corn and cottonseed meal increased weight gains of cattle wintered on dry range grass but not of cattle wintered on prairie hay. In an experiment by Gossett and Riggs (1956), trace minerals failed to increase the gains of steers fed a ration of low quality prairie hay and limited amounts of cottonseed meal and sorghum grain. However, replacement of part of the hay with dehydrated alfalfa leaf meal—which increased carotene, energy, and protein content of the ration—improved the rate of gain.

The purpose of the research reported in this paper was to collect additional information on the value of trace minerals in cattle fattening rations composed primarily of either corn or sorghum grain.

## Experimental Methods

Four experiments were conducted involving a total of 80 steer and heifer yearlings. All of the animals were purchased as calves and wintered and grazed at the Kansas Station prior to being used in the fattening tests reported here. Corn was fed in experiments I and III, and sorghum grain (milo) in experiments II and IV. In experiments I, II and III the lots fed additional trace minerals had been fed trace minerals in a previous wintering trial. During that trial their gains and those of the controls were approx-

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[3] The authors wish to express appreciation to the Calcium Carbonate Company, Chicago, for supplying the trace minerals used in experiments II, III, and IV.

imately the same. All steers used in experiments I, II and III were assigned to their respective lots initially on the basis of weight, 10 head to each lot. In experiment IV, the 20 yearling heifers were assigned to their respective lots on the basis of weight and prior treatment.

In experiment I the trace minerals were offered in a commercial trace mineralized salt, free-choice, which according to the supplier's specifications contained manganese, 0.170%; iron, 0.175%; copper, 0.033%; cobalt, 0.010%; iodine, 0.007% and sodium chloride, 99.058%. The trace minerals fed in experiment II, III, and IV were in a pre-mix which was added to the protein concentrate. This was fed to supply the following amounts, as calculated from the company specifications, in milligrams per head daily in the fattening ration: Manganese, 56.3; iodine, 1.97; cobalt, 1.25; iron, 46.13; copper, 3.65; and zinc, 3.42.

At the start of an experiment the animals were fed the concentrate portion of their rations twice daily until they were receiving a full feed of grain; then, they had access to a self-feeder. Prairie hay was either kept before the cattle at all times or fed in amounts readily eaten. Plain salt was available free-choice for all lots except in experiment I when the trace mineralized salt was offered free-choice to one lot and plain salt was offered free-choice to the other lot. Ground limestone was fed at the rate of 0.1 lb. per head daily with the protein concentrate.

A mineral analysis of feeds similar to those used in these experiments has been reported by Glendening *et al.* (1952).

## Results

In experiment I (table 1), the trace mineralized salt offered with a ration of coarse ground sorghum grain, cottonseed oil meal pellets (solvent extracted), prairie hay, and ground limestone had little effect on the rate of gain or feed efficiency of the steers. The carcass grades and marbling scores were slightly higher for the control steers. In experiment III the trace minerals fed with a ration of ground sorghum grain, prairie hay, soybean meal (expeller process), salt and ground limestone had no significant effect on daily gain or feed efficiency.

In experiment II (table 2), the steers fed trace minerals in a ration of ground corn, soybean pellets (expeller process), prairie hay, ground limestone and salt gained 0.58 lb. more per day than the controls ($P = 0.01$). This increase was most noticeable during the last 30 days of the test. The steers fed trace minerals ate more grain and utilized it more efficiently; their carcasses graded slightly higher than the control group and the amount of marbling was also in their favor.

Likewise in experiment IV, addition of trace minerals to the corn ration increased the daily gain of heifers 0.37 lb. over those not fed trace minerals ($P=0.01$). The heifers fed trace minerals ate slightly more grain and utilized it more efficiently.

TABLE 1. RESPONSE OF CATTLE TO TRACE MINERALS ADDED TO A SORGHUM GRAIN FATTENING RATION

| Experiment | Experiment I August 1 to December 6, 1952 (127 days) | | Experiment III August 1 to November 12, 1955 (104 days) | |
|---|---|---|---|---|
| Treatment | Lot 1 Control | Lot 2 [a] Trace mineral | Lot 1 Control | Lot 2 [b] Trace mineral |
| No. of cattle | 10 | 10 | 10 | 10 |
| Av. initial wt., lb. | 702 | 714 | 845 | 854 |
| Av. final wt., lb. | 1039 | 1045 | 1103 | 1119 |
| Gain per head, lb. | 337 | 331 | 258 | 265 |
| Av. daily gain, lb. | 2.65 | 2.60 | 2.48 | 2.55 |
| Av. daily feed, lb. | | | | |
| Ground sorghum grain | 19.31 | 19.08 | 19.73 | 19.20 |
| Protein concentrate | 2.00 | 2.00 | 1.51 | 1.51 |
| Prairie hay | 5.90 | 5.92 | 6.60 | 6.65 |
| Ground limestone | 0.10 | 0.10 | 0.10 | 0.10 |
| Salt | 0.03 | 0.02 [a] | 0.01 | 0.01 |
| Feed per 100 lb. gain, lb. | | | | |
| Ground sorghum grain | 726.63 | 732.20 | 795.31 | 753.39 |
| Protein concentrate | 75.25 | 76.73 | 60.89 | 59.28 |
| Prairie hay | 222.19 | 227.40 | 266.27 | 261.16 |
| Dressing percentage | 60.1 | 60.6 | 60.5 | 60.6 |
| Carcass grades | | | | |
| Av. choice | 4 | 1 | .. | 1 |
| Low choice | 3 | 3 | 1 | .. |
| High good | 2 | 1 | 3 | 4 |
| Av. good | 1 | 3 | 3 | 4 |
| Low good | .. | 2 | 3 | 1 |
| Degree of marbling [c] | 6.5 | 7.5 | 7.1 | 6.4 |

[a] A trace mineralized salt was offered free choice which contained the following minerals: Manganese, 0.170%; iron, 0.175%; copper, 0.033%; cobalt, 0.010%; iodine, 0.007%; sodium chloride, 99.058%.
[b] The trace minerals were fed as a trace mineral premix added to the protein concentrate to furnish the following amounts in milligrams per head daily in the ration: Manganese, 56.3; iodine, 1.97; cobalt, 1.25; iron, 46.13; copper, 3.65 and zinc, 3.42.
[c] Scores for degree of marbling: Modest, 6; small amount, 7; and slight amount, 8.

*Discussion.* Results obtained in experiments I and III with the sorghum grain rations are in agreement with those reported by Gossett and Riggs (1956) for a growing ration and by Pope *et al.* (1959) who reported that added trace minerals were of no benefit for fattening steers receiving sorghum grain, corn or sorghum silage, and soybean meal.

Results obtained in experiments II and IV with the corn rations, however, are in agreement with those of Klosterman *et al.* (1953, 1956). The cattle gained an average of 0.47 lb. more per head daily when trace minerals were added to the ration; they required 9.2 lb. less protein concentrate, 53.5 lb. less corn, and 17.3 lb. less prairie hay to produce 100 lb. of gain. Furthermore, these results have been confirmed in a later trial with heifers

TABLE 2. RESPONSE OF CATTLE TO TRACE MINERALS ADDED TO A CORN FATTENING RATION

| Experiment | Experiment II July 31 to November 7, 1953 (99 days) | | Experiment IV July 24 to November 5, 1957 (104 days) | |
|---|---|---|---|---|
| Treatment | Lot 1 Control | Lot 2 Trace mineral[a] | Lot 1 Control | Lot 2 Trace mineral[a] |
| No. of cattle | 10 | 10 | 10 | 10 |
| Av. initial wt., lb. | 738 | 727 | 716 | 717 |
| Av. final wt., lb. | 980 | 1026 | 977 | 1016 |
| Gain per head, lb. | 242 | 299 | 261 | 299 |
| Av. daily gain, lb. | 2.44 | 3.02** | 2.51 | 2.88** |
| Av. daily feed, lb. | | | | |
| Corn | 14.09 | 15.88 | 16.61 | 17.43 |
| Protein concentrate | 1.44 | 1.46 | 1.49 | 1.47 |
| Prairie hay | 4.88 | 4.62 | 3.60 | 3.51 |
| Ground limestone | 0.09 | 0.10 | 0.09 | 0.09 |
| Salt | 0.09 | 0.08 | 0.02 | 0.02 |
| Feed per 100 lb. gain, lb. | | | | |
| Corn | 576.61 | 525.25 | 661.87 | 606.35 |
| Protein concentrate | 58.88 | 48.41 | 59.25 | 51.22 |
| Prairie hay | 166.81 | 153.14 | 143.30 | 122.24 |
| Dressing percentage | 60.6 | 60.7 | 59.6 | 59.6 |
| Carcass grades | | | | |
| Av. choice | .. | 1 | .. | 1 |
| Low choice | 1 | 3 | 4 | 4 |
| High good | 2 | 3 | 3 | 3 |
| Av. good | 4 | 2 | 2 | 1 |
| Low good | 3 | .. | 1 | 1 |
| Commercial | .. | 1 | .. | .. |
| Degree of marbling[b] | 8.3 | 7.2 | 6.6 | 6.5 |
| Size of rib eye, sq. in. | .. | .. | 12.33 | 11.98 |
| Fat over rib eye, in. | .. | .. | 0.616 | 0.773 |
| Firmness[c] | .. | .. | 3.1 | 3.1 |

** Significant at the 1% level.

[a] The trace minerals were fed as a trace mineral premix added to the protein concentrate to furnish the following amounts in milligrams per head daily in the ration: Manganese, 56.3; iodine, 1.97; cobalt, 1.25; iron, 46.13; copper, 3.65 and zinc, 3.42.

[b] Scores for degree of marbling; Modest, 6; small amount, 7; and slight amount, 8.

[c] Scores for degree of firmness: Moderately firm, 3; modestly firm, 4.

fed a similar fattening ration with and without trace minerals (Smith *et al.*, 1959).

The difference in response obtained with the sorghum grain and corn rations may be related to difference in mineral composition of the grains. Glendening *et al.* (1952) found that sorghum grain contained 10 ppm. more copper, 7 ppm. more manganese, 20 ppm. less iron and 0.09 ppm. less cobalt than corn. Beeson (1941) reported that sorghum grain contained 6 ppm. less zinc than corn. These differences are small, however, in proportion to total mineral intake.

TABLE 1. RESPONSE OF CATTLE TO TRACE MINERALS ADDED TO A SORGHUM GRAIN FATTENING RATION

| Experiment | Experiment I August 1 to December 6, 1952 (127 days) | | Experiment III August 1 to November 12, 1955 (104 days) | |
|---|---|---|---|---|
| Treatment | Lot 1 Control | Lot 2 [a] Trace mineral | Lot 1 Control | Lot 2 [b] Trace mineral |
| No. of cattle | 10 | 10 | 10 | 10 |
| Av. initial wt., lb. | 702 | 714 | 845 | 854 |
| Av. final wt., lb. | 1039 | 1045 | 1103 | 1119 |
| Gain per head, lb. | 337 | 331 | 258 | 265 |
| Av. daily gain, lb. | 2.65 | 2.60 | 2.48 | 2.55 |
| Av. daily feed, lb. | | | | |
| Ground sorghum grain | 19.31 | 19.08 | 19.73 | 19.20 |
| Protein concentrate | 2.00 | 2.00 | 1.51 | 1.51 |
| Prairie hay | 5.90 | 5.92 | 6.60 | 6.65 |
| Ground limestone | 0.10 | 0.10 | 0.10 | 0.10 |
| Salt | 0.03 | 0.02 [a] | 0.01 | 0.01 |
| Feed per 100 lb. gain, lb. | | | | |
| Ground sorghum grain | 726.63 | 732.20 | 795.31 | 753.39 |
| Protein concentrate | 75.25 | 76.73 | 60.89 | 59.28 |
| Prairie hay | 222.19 | 227.40 | 266.27 | 261.16 |
| Dressing percentage | 60.1 | 60.6 | 60.5 | 60.6 |
| Carcass grades | | | | |
| Av. choice | 4 | 1 | .. | 1 |
| Low choice | 3 | 3 | 1 | .. |
| High good | 2 | 1 | 3 | 4 |
| Av. good | 1 | 3 | 3 | 4 |
| Low good | .. | 2 | 3 | 1 |
| Degree of marbling [c] | 6.5 | 7.5 | 7.1 | 6.4 |

[a] A trace mineralized salt was offered free choice which contained the following minerals: Manganese, 0.170%; iron, 0.175%; copper, 0.033%; cobalt, 0.010%; iodine, 0.007%; sodium chloride, 99.058%.
[b] The trace minerals were fed as a trace mineral premix added to the protein concentrate to furnish the following amounts in milligrams per head daily in the ration: Manganese, 56.3; iodine, 1.97; cobalt, 1.25; iron, 46.13; copper, 3.65 and zinc, 3.42.
[c] Scores for degree of marbling: Modest, 6; small amount, 7; and slight amount, 8.

*Discussion.* Results obtained in experiments I and III with the sorghum grain rations are in agreement with those reported by Gossett and Riggs (1956) for a growing ration and by Pope *et al.* (1959) who reported that added trace minerals were of no benefit for fattening steers receiving sorghum grain, corn or sorghum silage, and soybean meal.

Results obtained in experiments II and IV with the corn rations, however, are in agreement with those of Klosterman *et al.* (1953, 1956). The cattle gained an average of 0.47 lb. more per head daily when trace minerals were added to the ration; they required 9.2 lb. less protein concentrate, 53.5 lb. less corn, and 17.3 lb. less prairie hay to produce 100 lb. of gain. Furthermore, these results have been confirmed in a later trial with heifers

TABLE 2. RESPONSE OF CATTLE TO TRACE MINERALS ADDED TO A CORN FATTENING RATION

| Experiment | Experiment II July 31 to November 7, 1953 (99 days) | | Experiment IV July 24 to November 5, 1957 (104 days) | |
|---|---|---|---|---|
| Treatment | Lot 1 Control | Lot 2 Trace mineral[a] | Lot 1 Control | Lot 2 Trace mineral[a] |
| No. of cattle | 10 | 10 | 10 | 10 |
| Av. initial wt., lb. | 738 | 727 | 716 | 717 |
| Av. final wt., lb. | 980 | 1026 | 977 | 1016 |
| Gain per head, lb. | 242 | 299 | 261 | 299 |
| Av. daily gain, lb. | 2.44 | 3.02** | 2.51 | 2.88** |
| Av. daily feed, lb. | | | | |
| Corn | 14.09 | 15.88 | 16.61 | 17.43 |
| Protein concentrate | 1.44 | 1.46 | 1.49 | 1.47 |
| Prairie hay | 4.88 | 4.62 | 3.60 | 3.51 |
| Ground limestone | 0.09 | 0.10 | 0.09 | 0.09 |
| Salt | 0.09 | 0.08 | 0.02 | 0.02 |
| Feed per 100 lb. gain, lb. | | | | |
| Corn | 576.61 | 525.25 | 661.87 | 606.35 |
| Protein concentrate | 58.88 | 48.41 | 59.25 | 51.22 |
| Prairie hay | 166.81 | 153.14 | 143.30 | 122.24 |
| Dressing percentage | 60.6 | 60.7 | 59.6 | 59.6 |
| Carcass grades | | | | |
| Av. choice | .. | 1 | .. | 1 |
| Low choice | 1 | 3 | 4 | 4 |
| High good | 2 | 3 | 3 | 3 |
| Av. good | 4 | 2 | 2 | 1 |
| Low good | 3 | .. | 1 | 1 |
| Commercial | .. | 1 | .. | .. |
| Degree of marbling[b] | 8.3 | 7.2 | 6.6 | 6.5 |
| Size of rib eye, sq. in. | .. | .. | 12.33 | 11.98 |
| Fat over rib eye, in. | .. | .. | 0.616 | 0.773 |
| Firmness[c] | .. | .. | 3.1 | 3.1 |

** Significant at the 1% level.

[a] The trace minerals were fed as a trace mineral premix added to the protein concentrate to furnish the following amounts in milligrams per head daily in the ration: Manganese, 56.3; iodine, 1.97; cobalt, 1.25; iron, 46.13; copper, 3.65 and zinc, 3.42.

[b] Scores for degree of marbling: Modest, 6; small amount, 7; and slight amount, 8.

[c] Scores for degree of firmness: Moderately firm, 3; modestly firm, 4.

fed a similar fattening ration with and without trace minerals (Smith *et al.*, 1959).

The difference in response obtained with the sorghum grain and corn rations may be related to difference in mineral composition of the grains. Glendening *et al.* (1952) found that sorghum grain contained 10 ppm. more copper, 7 ppm. more manganese, 20 ppm. less iron and 0.09 ppm. less cobalt than corn. Beeson (1941) reported that sorghum grain contained 6 ppm. less zinc than corn. These differences are small, however, in proportion to total mineral intake.

## Summary

Four feeding trials were conducted to study the value of adding a combination of trace minerals to fattening rations for cattle. Addition of cobalt, copper, iron, iodine, manganese and zinc to fattening rations consisting of sorghum grain, protein concentrate, prairie hay, ground limestone and salt was without effect on gain or feed efficiency.

Addition of these minerals to a similar fattening ration containing corn in place of sorghum grain produced a highly significant increase in rate of gain. The cattle gained 0.47 lb. more per head daily, on the average, for the two trials when trace minerals were added to the corn ration, and feed efficiency was improved.

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# ABSORPTION OF DIETHYLSTILBESTROL PELLETS IN STEERS

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IN controlled experiments with cattle, it has been found that a single implantation of 36 mg. of diethylstilbestrol (stilbestrol) exerts a growth promoting effect over a period of 150–238 days (Klosterman *et al.*, 1956; Klosterman *et al.*, 1957; Dowe *et al.*, 1957; Perry *et al.*, 1958). However, to date no published data have come to the authors' attention on the direct determination of rate of absorption of stilbestrol from stilbestrol pellets in steers throughout the feeding period. The experiments reported herein were conducted to determine the rate of absorption of stilbestrol when the material was subcutaneously implanted in the ear.

## Methods and Materials

Three pilot groups of stilbestrol pellets were laboratory tested for disintegration time in 50% aqueous acetone. The groups of pellets had identical chemical composition and ingredient make-up. The major variables were the percent solvent in the formula granulation at time of pelleting and the compression applied at time of pelleting. The disintegration times for the pellets used in Experiments 1, 2, and 3 were 19, 40 and 18 minutes, respectively, with corresponding standard deviations of 1.0, 6.6, and 3.0 minutes. Pellets designated as number 1, 2, and 3 were used in Experiments 1, 2, and 3, respectively.

In Experiment 1, 24 steers averaging 845 lb. each were implanted with 24 mg. of stilbestrol (two 12-mg. pellets). Residues of both pellets were removed from each of six randomly selected steers at 28, 56, 84 and 112 days subsequent to implanting. During the 112-day period these steers received a full feed of ground ear corn plus 2 lb. of a protein supplement and 2 lb. of alfalfa hay per steer daily. In Experiments 2 and 3, which ran concurrently, eight and nine steers, respectively, averaging 765 lb. each, were implanted with 36 mg. stilbestrol (three 12-mg. pellets). In Experiments 2 and 3 all pellet residues were removed from two of the steers in each experiment at 28-day intervals, except in Experiment 3 when pellets were also removed from three steers at the 112-day period. The steers in Experiments 2 and 3 were maintained on pasture the first 28 days and in dry lot thereafter. While in dry lot the steers were limited-fed ground ear corn, protein supplement and alfalfa hay plus a full feed of ground cobs.

Prior to implantation 10 pellets of each batch from which the respective groups of steers were to be implanted were individually weighed and

assayed for stilbestrol. The results provided a base line for determining rate of absorption in each experiment. Implantations were made subcutaneously about half way between the tip and base of one ear. Stilbestrol pellets for any one steer were deposited at one implant site. Pellet residues were excised after immobilizing the steer's head in a chute and applying a topical anesthetic to the area of implantation. After removal, pellet residues were cleaned of extraneous material, dried, individually weighed and assayed for stilbestrol content by a modification of the method of Goodyear *et al.* (1954).

A fattening trial was conducted in which steers were implanted with pellets from the same batch as used in Experiment 2 of the absorption studies. Replicated lots of eight steers served as the control, and in a single lot of eight steers each was implanted with 36 mg. of stilbestrol (three 12-mg. pellets). Average initial weight of the steers was 696 lb. During the 169-day feeding period the steers were full-fed cracked shelled corn and 2 lb. of supplement plus 3 lb. of alfalfa hay per head daily. While the steers were being raised to a full feed of corn a limited amount of ground cob was fed.

## Results and Discussion

Table 1 presents the residual weights of the pellets and the weight of stilbestrol in the pellet residues at the stated intervals in the three experiments.

The rate of absorption of stilbestrol from the pellet can be described by the following mathematical expression: $Y=kae^{-bt}$. In this equation Y=mg. of stilbestrol per pellet recovered at each interval, k = constant, a = mg. of stilbestrol per pellet at time of implantation, e = base of natural logarithm, b = rate of absorption (mg. per day) and t = time in days. The values for the pellets used in Experiments 1, 2, and 3 were $Y=0.837ae^{-0.00862t}$, $Y=0.991ae^{-0.00950t}$ and $Y=0.968ae^{-0.00720t}$ respectively. The half-life of the pellets (the time for one half of the pellet to be absorbed) for Experiments 1, 2, and 3 was 80, 73, and 96 days, respectively.

The fit of these equations to observed absorption for the three experiments is shown in table 2. Extrapolation of the calculated values showed at zero time a value slightly less than that for an intact pellet, particularly in Experiment 1. This is probably due to a modification of the rate of absorption during the first few days as a result of some slight crushing of the pellet at implantation plus the effect of large quantities of body fluids which surround the pellet immediately after implantation as in the case of introduction of any foreign body. In Experiments 2 and 3 this initial absorption during the first 28 days was much slower than in Experiment 1.

In these experiments it was not possible to ascertain whether level of implantation had any effect upon rate of absorption; however, calculations

TABLE 1. RECOVERY OF PELLETS AND STILBESTROL AT 28-DAY INTERVALS [a]

| | Residues per pellet at intervals | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 28 Days | | 56 Days | | 84 Days | | 112 Days | |
| Replicate [b] | Pellet | Stilb. | Pellet | Stilb. | Pellet | Stilb. | Pellet | Stilb. |
| | mg. | mg. | mg. | mg. | mg. | mg. | mg. | mg. |
| | | | | Experiment 1 | | | | |
| a | 9.2 | 7.7 | 7.8 | 7.2 | 7.0 | 5.3 | 7.5 | 6.3 |
| b | 9.0 | 7.5 | 8.6 | 7.7 | 6.7 | 4.8 | 7.9 | 6.5 |
| a | 9.4 | 8.3 | 7.4 | 6.5 | ... | ... | ... | ... |
| b | 9.2 | 7.8 | 7.9 | 6.9 | ... | ... | ... | ... |
| a | 9.7 | 8.4 | 10.5 | 8.6 | ... | ... | 4.4 | 3.3 |
| b | 10.0 | 8.7 | 9.7 | 7.9 | ... | ... | 5.0 | 3.9 |
| a | 9.1 | 7.7 | 4.9 | 4.2 | 8.5 | 5.9 | 3.7 | 2.9 |
| b | 10.1 | 8.3 | 3.2 | 2.9 | 7.4 | 5.5 | 3.6 | 2.9 |
| a | 10.3 | 8.6 | 9.1 | 7.4 | 6.0 | 4.7 | ... | ... |
| b | 10.2 | 8.7 | 9.1 | 7.8 | 5.5 | 4.2 | ... | ... |
| a | 10.0 | 8.4 | 7.7 | 6.3 | 2.6 | ... [c] | 3.5 | 2.6 |
| b | 9.8 | 8.4 | 8.6 | 7.5 | 5.1 | ... | 6.6 | 5.6 |
| Average | 9.6 | 8.2 | 7.9 | 6.8 | 6.8 | 5.1 | 5.3 | 4.3 |
| | | | | Experiment 2 | | | | |
| a | 10.7 | 9.3 | 9.0 | 7.3 | 6.0 | 5.2 | 5.2 | 4.2 |
| b | 10.5 | 9.0 | 8.6 | 6.9 | 5.5 | 5.1 | 5.0 | 4.2 |
| c | 10.0 | 8.4 | 7.7 | 6.5 | ... | ... | 4.9 | 4.0 |
| a | 10.0 | 8.9 | 8.8 | 7.2 | 7.4 | 6.3 | 3.6 [d] | 3.1 [d] |
| b | 9.3 | 8.1 | 8.4 | 6.6 | ... | ... | 3.6 | 3.1 |
| c | 10.5 | 9.4 | 8.4 | 6.5 | ... | ... | 3.6 | 3.1 |
| Average | 10.2 | 8.8 | 8.4 | 6.8 | 6.3 | 5.5 | 4.3 | 3.6 |
| | | | | Experiment 3 | | | | |
| a | 11.4 | 10.4 | 7.2 | 6.2 | 6.9 | 5.6 | 6.2 | 4.7 |
| b | 12.0 | 10.7 | 7.8 | 6.4 | 8.1 | 6.9 | 6.7 | 4.8 |
| c | 10.1 | 8.8 | 7.5 | 6.3 | 7.5 | 6.6 | 6.3 | 4.8 |
| a | 10.0 | 8.6 | 8.9 | 7.6 | 7.4 | 6.8 | 5.9 | 4.6 |
| b | 11.0 | 9.3 | 9.5 | 8.1 | 7.4 | 6.5 | 6.1 | 4.8 |
| c | 12.1 | 10.4 | 10.4 | 9.3 | 6.3 | 5.4 | 6.3 | 4.8 |
| a | | | | | | | 7.8 | 6.2 |
| b | | | | | | | 7.6 | 6.2 |
| c | | | | | | | ... | ... |
| Average | 11.1 | 9.7 | 8.6 | 7.3 | 7.3 | 6.3 | 6.6 | 5.1 |

[a] Initial pellet weights for experiments 1, 2, and 3 were 15.2, 14.9 and 14.7 mg., respectively. Initial stilbestrol content per pellet for experiments 1, 2, and 3 were 12.5, 11.4 and 11.8 mg., respectively.

[b] Pellets from each steer were considered as replicates.

[c] Assays were lost at 84-day period.

[d] The three pellets were removed in six pieces. The pieces were weighed and assayed in the aggregate and that value divided by three.

of a theoretical rate of absorption based on pellet surface area by a first order reaction equation ($Y=kae^{-bt}$) showed that the theoretical and empirical absorptions are in close agreement. The theoretical calculation accounted for 86% of the actual absorption observed *in vivo* with pellet number 2. This indicated that absorption rate of diethylstilbestrol pellets in steers is a function of the surface area of a pellet and was not necessarily related to the total number of pellets implanted.

TABLE 2. STILBESTROL RESIDUES BY ASSAY AND BY CALCULATION FROM EQUATION

| Days after implantation | Stilbestrol per pellet by assay, mg. | Stilbestrol per pellet calculated, mg. |
|---|---|---|
| | Experiment 1 | |
| 0 | 12.50 | 10.12 |
| 28 | 8.21 | 8.37 |
| 56 | 6.75 | 6.62 |
| 84 | 5.07 | 5.23 |
| 112 | 4.26 | 4.13 |
| | Experiment 2 | |
| 0 | 11.80 | 11.37 |
| 28 | 8.85 | 8.78 |
| 56 | 6.83 | 6.79 |
| 84 | 5.53 | 5.24 |
| 112 | 3.62 | 4.05 |
| | Experiment 3 | |
| 0 | 11.40 | 11.32 |
| 28 | 9.70 | 9.26 |
| 56 | 7.32 | 7.58 |
| 84 | 6.30 | 6.21 |
| 112 | 5.11 | 5.09 |

Table 3 shows the stilbestrol absorbed per pellet in each 28-day interval for the three experiments. Absorption by periods appeared to be most uniform for the pellet in Experiment 2. On the basis of the amount of stilbestrol absorbed in each of the four 28-day periods the average amount of stilbestrol absorbed daily per pellet for the 112-day period was 0.074, 0.073 and 0.056 mg. for Experiments 1, 2, and 3, respectively. At the time of excising the pellets from the ear of the steers there was no evidence of encapsulation.

The pellet used in absorption Experiment 2 was selected for the feedlot trial to determine whether the results of the absorption studies would be substantiated by weight gains obtained in controlled feeding conditions. The pellet used in Experiment 1 was not used because of its erratic absorption during the four 28-day test periods, and the pellet used in Experiment 3 was considered to be absorbed too slowly for optimum

TABLE 3. STILBESTROL ABSORBED PER PELLET BY 28-DAY INTERVALS

| Experiment no. | 0–28 Days | 29–56 Days | 57–84 Days | 85–112 Days | 0–112 Days |
|---|---|---|---|---|---|
| | mg. | mg. | mg. | mg. | mg. |
| 1 | 4.28 | 1.46 | 1.68 | 0.81 | 8.23 |
| 2 | 2.94 | 1.99 | 1.29 | 1.90 | 8.12 |
| 3 | 1.71 | 2.41 | 1.01 | 1.20 | 6.33 |

growth effects. Disintegration time of the stilbestrol pellets in 50% aqueous acetone was not closely correlated with absorption rates.

The results of the feed-lot trial are presented in table 4. The implanted group gained at a rate in excess of the control for all except one of the six 28-day periods, indicating that the pellet used in absorption Experiment 2 did exert a growth promoting effect throughout the 169-day feeding

TABLE 4. RATE OF GAIN OF CONTROL AND STILBESTROL-IMPLANTED STEERS

| Treatment | No. of animals | Average daily gain (lb.) by intervals | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1st 28 days | 2nd 28 days | 3rd 28 days | 4th 29 days | 5th 27 days | 6th 29 days | Total 169 days |
| Control 1 | 8 | 1.90 | 2.56 | 2.25 | 2.17 | 2.43 | 3.09 | 2.40 |
| Control 2 | 8 | 2.20 | 2.25 | 2.60 | 2.42 | 2.60 | 2.52 | 2.43 |
| Average | | 2.05 | 2.40 | 2.42 | 2.30 | 2.52 | 2.80 | 2.42 |
| 36 mg. stilbestrol implantation | 8 | 2.27 | 2.71 | 3.01 | 2.68 | 2.33 | 3.39 | 2.74 |
| Increased gain over control by periods, lb. | | 6.2 | 8.7 | 16.5 | 11.0 | −7.8 | 17.1 | 54.1 |

Analysis of variance of weight gains

| Source of variation | Degrees of freedom | Mean squares | F |
|---|---|---|---|
| Control vs. treatment | 1 | 3.254863 | 5.99* |
| Effect of slope | 1 | 5.443737 | 10.01** |
| Divergence of slope | 1 | 0.000017 | ..... |
| Variation about both curves | 140 | 0.543900 | ..... |
| Variation about control | 94 | 0.539610 | ..... |
| Variation about treatment | 46 | 0.552669 | 1.02 |

* Significant at 5% level.
** Significant at 1% level.

period. Calculations from absorption Experiment 2 indicated that the pellet should be effective for a 150- to 175-day period. Analysis of variance was calculated with special attention given to the slope of the fitted regression curves of average daily gains (Bliss, 1952). The individual average daily gains by period by animal were used in the analysis of variance. The equations for the curves of the control and treated groups are: $ADG_c = 2.017 + 0.1137T$, and $ADG_t = 2.335 + 0.1141T$, respectively, where T = number of 28-day periods.

Since the curves were essentially parallel, the slopes can be considered estimates of the same parameter and the data pooled. The combined slope was 0.1138. An analysis of variance was then conducted to test the significance of the various components. The average daily gain of the treated group was significantly higher than that of the control. The effect of slope was highly significant which implies that, during the period of the test (169 days) the average daily gain of both groups increased. The divergence of slope was not significant and indicated that the two curves were, in

fact, substantially parallel and that the average daily gain was increasing at the same rate in both groups. The variation about the control curve and the variation about the treatment curve were approximately equal and showed that the experimental error was equal in both groups. Because of this, both estimates of error were pooled and the resulting error term was used to test the other effects. The horizontal distance between curves was:

$$M = \frac{2.734 - 2.415}{0.1138} = 2.80$$

which indicates that the average daily gain of the treated group has effectively been moved forward in time in respect to the control group by 2.80 periods of time or 78.5 days.

Turner *et al.* (1956) assayed feces from steers receiving 10 mg. of stilbestrol per day orally and found that the level of stilbestrol in the feces was similar to that in the feed; however, he made no estimate of the daily absorption of the 10-mg. feeding level. In balance studies with wether lambs approximately 25% of the orally administered stilbestrol was found in the urine (Story *et al.*, 1957). This must be taken as a minimum absorption as excretion by the way of the bile duct may account for excretion of part of the absorbed stilbestrol. Mitchell *et al.* (1957) using tritium labelled stilbestrol in two steers found that 20% of the radioactive stilbestrol was excreted in the urine. Melampy *et al.* (1959), using three ovariectomized cows found that slightly more than 20% of a 10-mg. oral dose appeared in the urine. These three studies are in close agreement for urinary excretion of orally administered stilbestrol in ruminants. From the data of Mitchell *et al.* (1957) and Melampy *et al.* (1959) it appears that at least 2 mg. of stilbestrol would be absorbed daily from the customary feeding level of 10 mg. per steer per day. With the pellet used in absorption Experiment 2 and in the described fattening trial only 24.5 mg. of stilbestrol would be absorbed from a 36-mg. implantation in a 112-day feeding period, or 0.22 mg. per day. Yet a 36-mg. implantation of stilbestrol provides a growth stimulus in 140- to 238-day feeding periods similar to that provided by an oral intake of 10 mg. per head daily (Klosterman *et al.*, 1956; Klosterman *et al.*, 1957; Perry *et al.*, 1958; Dowe *et al.*, 1957).

The stilbestrol absorbed from a pellet would first appear in the peripheral circulation as opposed to hepatic circulation for orally fed stilbestrol. What effect these separate routes for entry of the stilbestrol into metabolism would have in terms of the amount of stilbestrol to produce the desired growth promoting effect in steers is not known. Furthermore, it is not known if the free stilbestrol or a conjugated form is necessary for growth stimulating activity in steers. While the route of entry of the stilbestrol into metabolism may be a factor in determining the amount of stilbestrol required to produce a certain effect, this does not necessarily indicate differences in terms of target organs upon which the stilbestrol acts.

## Summary

In three experiments a total of 41 steers were implanted with experimental 12-mg. diethylstilbestrol pellets. In each experiment pellet residues were removed from randomly selected steers at 28, 56, 84 and 112 days subsequent to implantation. The rate of absorption of the diethylstilbestrol from the pellets was found to follow closely that of a first order reaction. The half life of pellets 1, 2, and 3 was 80, 73 and 96 days, respectively. Over the 112-day period the quantities of stilbestrol absorbed daily per 12-mg. pellet were 0.074, 0.073 and 0.056 mg. for pellets 1, 2, and 3, respectively. Pellet 2 was selected for testing in feed-lot because rate of absorption suggested this pellet should be uniformly effective in stimulating additional gains for at least a 150–175-day period. In a 169-day fattening trial, pellet 2 increased gains over the total period with no indication that there was a reduction in rate of gain during the later phases of the trial.

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# BIURET—A SOURCE OF NPN FOR RUMINANTS [1]

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WHEN used at levels to furnish a substantial part of the animal's requirements for nitrogen, urea and ammonium salts, which release absorbable nitrogenous degradation products quickly, must be used with a certain degree of caution. This might be expected to be particularly true when used in feeds which are fed periodically as in the supplemental range feeding of cattle and sheep or in dairy cattle feeding. The toxicity of urea has been reported by numerous investigators. It has been demonstrated that when relatively large quantities of urea are administered to animals in a short period of time, digestive disturbances, ataxia, or even death will occur (Dinning *et al.*, 1948; Gallup *et al.*, 1953).

It would appear that urea nitrogen fed intermittently would not be utilized by the rumen flora as well as nitrogen from less-soluble NPN compounds which might release their nitrogen at a slower rate. However, when the intervals between feed intake are short and the amount of feed consumed at any one time is relatively small, as in continuous or self-feeding of lambs, satisfactory performances may be obtained on rations in which urea furnishes almost all of the nitrogen in the ration (Starks *et al.*, 1953; Albert *et al.*, 1956). It is postulated that the ideal NPN compound would be nontoxic and would release available nitrogen gradually at a rate to support continuously an active rumen flora with varying intervals and levels of feed and/or nitrogen intake.

This report includes the results of a series of studies which were made to determine to what extent and under what conditions biuret (a condensation product of urea) might serve a satisfactory source of NPN for ruminants. Biuret, which is much less soluble than urea and apparently is not affected by the urease activity of the rumen, may release its nitrogen at a slower rate than urea thus reducing the hazards of a rapid release of absorbable nitrogenous compounds which may then diffuse directly into the surrounding tissues or fluids. Repp *et al.* (1955) found very little change in the blood urea or ammonia after feeding large amounts of biuret and suggested that ammonia was released very slowly, if at all, during digestion. In addition, biuret may have less influence than urea on the acceptability of rations.

Since biuret has been reported to be toxic to plants (Jones, 1954; Sanford

[1] Supported in part by a grant-in-aid from Grace Chemical Company, Memphis, Tennessee. The biuret was purchased as a pure product from two suppliers.

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*et al.*, 1954; Haas *et al.*, 1954) and because of poor rumen bacterial growth and low cellulose digestion *in vitro* in a biuret medium (Belasco, 1954) three tests were made of its toxicity to sheep. After the toxicity tests indicated that biuret was not acutely toxic, a metabolism study was conducted to evaluate biuret as an NPN source of nitrogen for sheep. The study was designed to investigate three sources of supplemental nitrogen (urea, a mixture of urea and biuret, and biuret) at two levels of feed intake (maintenance and 150% of maintenance).

Beef cattle are frequently wintered on low-protein forages and a protein or protein-energy supplement. The observations made on the toxicity tests and the nitrogen balance studies in sheep supported the suggestion that biuret might be a satisfactory NPN compound for beef cattle. Consequently, a metabolism study was conducted with steers.

Since the toxicity tests indicated little or no immediate danger to sheep from biuret consumed or administered and because of positive nitrogen balances in the animals receiving a substantial part of the nitrogen as biuret nitrogen, a growth and reproduction study was conducted to determine the adequacy, over a considerable period of time, of rations in which urea or biuret furnished most of the ration nitrogen.

## Experimental Procedure

*Toxicity Tests. Sheep.* In the first test 375 gm. of biuret were mixed with 10 lb. of a fattening ration and fed in three consecutive equal portions, approximately 12 hours apart, to a 146-lb. ewe that had been penned without feed for 10 hours. In the second test 30 gm., 60 gm., and 90 gm., respectively, of biuret were given as a drench to three ewes weighing from 133 to 155 lb. In the third and most critical test two grade wether lambs weighing approximately 85 lb. each were given, as a drench, 175 gm. and 275 gm. of biuret, respectively. The 275-gm. drench contained more than twice as much biuret as the amount of urea reported to be lethal to a 500-lb. steer (Dinning *et al.*, 1948).

*Metabolism. Lambs.* The experimental animals were grade wether lambs weighing initially from 64 to 72 lb. The basal feed mixture containing 0.332% nitrogen consisted of the following ingredients by parts: Ground corncobs 57.9, corn starch 20.0, cerelose 10.0, mineral mix 4.0, wheat germ oil 0.5, choline chloride 0.1, and vitamin A and D concentrate 0.25. The basal feed mixture was supplemented with urea, biuret or both urea and biuret to provide additional and equal nitrogen for the test rations on the basis of urea containing 46.65% nitrogen and biuret containing 40.77% nitrogen. Subsequent analysis showed that the urea contained 46.34% nitrogen and that the biuret contained 35.73% nitrogen. Consequently, the urea ration contained more nitrogen than the biuret ration. The test rations, as designated, were made as follows: "urea" ration made by adding 1,816 gm. of urea to 100 lb. of the basal feed mixture; "urea-biuret" ration

TABLE 1. THE EXPERIMENTAL DESIGN, NITROGEN INTAKE, APPARENT DIGESTION COEFFICIENT OF NITROGEN, AND NITROGEN BALANCE OF LAMBS FED THREE SOURCES OF NPN AT TWO LEVELS OF FEEDING TWICE DAILY[a]

| Lamb no. | Trial | Nitrogen intake | Apparent digestion coefficient of nitrogen | Nitrogen balance[b] |
|---|---|---|---|---|
| | | gm. | | gm. |
| | | | "Urea" ration | |
| 4290 | I | 12.6 | 76 | 1.3 |
| 4257 | | 12.6 | 76 | 1.5 |
| 4080 | II | 12.6 | 74 | —0.3 |
| 4194[c] | | 12.6 | 75 | —2.1 |
| 4360 | III | 12.6 | 77 | 0.6 |
| 4150 | | 12.6 | 73 | 0.5 |
| Average | | | 75 | 0.25(2.6) |
| 4290 | IV | 18.9 | 75 | 3.3 |
| 4257 | | 18.9 | 74 | 2.5 |
| 4080 | V | 18.9 | 73 | 3.3 |
| 4194 | | 18.9 | 76 | 3.5 |
| 4360 | VI | 18.5[d] | 77 | 2.7 |
| 4150 | | 16.2[d] | 72 | 3.4 |
| Average | | | 74 | 3.12(22.8) |
| | | | "Urea-Biuret" ration | |
| 4290 | II | 12.0 | 71 | 1.1 |
| 4257 | | 12.0 | 66 | 0.9 |
| 4080 | III | 12.0 | 72 | 1.4 |
| 4194[c] | | 12.0 | 77 | 0.8 |
| 4360 | I | 12.0 | 68 | 0.2 |
| 4150 | | 12.0 | 66 | 0.9 |
| Average | | | 70 | 0.88(10.5) |
| 4290 | V | 17.9 | 71 | 5.4 |
| 4257 | | 17.9 | 70 | 5.3 |
| 4080 | VI | 17.9 | 74 | 4.3 |
| 4194 | | 17.9 | 76 | 3.8 |
| 4360 | IV | 17.9 | 66 | 2.1 |
| 4150 | | 17.9 | 64 | 2.8 |
| Average | | | 70 | 3.95(31.6) |
| | | | "Biuret" ration | |
| 4290 | III | 11.3 | 65 | 4.0 |
| 4257 | | 11.3 | 60 | 3.0 |
| 4080 | I | 11.3 | 68 | 1.3 |
| 4194[c] | | 9.0[d] | 62 | 2.4 |
| 4360 | II | 11.3 | 58 | —0.5 |
| 4150 | | 11.3 | 61 | —0.3 |
| Average | | | 62 | 1.65(24.3) |
| 4290 | VI | 12.9[d] | 72 | 4.2 |
| 4257 | | 15.4[d] | 67 | 4.4 |
| 4080 | IV | 16.9 | 63 | 2.3 |
| 4194 | | 16.9 | 65 | 0.4 |
| 4360 | V | 16.3[d] | 69 | 2.9 |
| 4150 | | 14.1[d] | 64 | 3.0 |
| Average | | | 66 | 2.87(28.1) |

[a] Lambs were fed 300 gm. of ration twice daily during Trials I, II, and III, and 450 gm. twice daily during Trials IV, V, and VI.

[b] Nitrogen balance as a percent of apparently digested nitrogen is shown in parenthses.

[c] Lamb 4194 was used in the last five collection periods, replacing lamb 4117 which was used in Period I but failed to eat satisfactorily.

[d] Feed not consumed was weighed back.

made by adding 908 gm. of urea and 1,040 gm. of biuret to 100 lb. of the basal feed mixture; and, "biuret" ration made by adding 2,080 gm. of biuret to 100 lb. of the basal feed mixture.

The reversal technique was used so that on each level of feed intake each lamb received each ration sometime during the study. Each animal was randomly allotted to the first ration and thereafter received the rations according to the sequence in the design which is shown in table 1 with the results.

All animals were group-fed the basal feed mixture supplemented with 4% urea for a 19-day adjusting period prior to the first preliminary period. The lambs were individually and equally fed the test rations during the preliminary periods for each trial. Lambs on the lower level of feed intake were offered 300 gm. of one of the test rations twice daily. Lambs on the higher level of feed intake were offered 450 gm. of one of the test rations twice daily.

The length of the preliminary periods were: 18 days for Trial I, 11 days for Trial II, 10 days for Trial III, 7 days for Trial IV, and 4 days each for Trials V and VI. The later trials had to be shortened because of failure to receive biuret which was delayed in shipment.

During the collection periods the level and frequency of feeding were the same as in the preliminary periods. Metabolism cages similar to those described by Bratzler (1951) with provisions for the separation and quantitative collection of feces and urine were used. All of the feces and a 10% aliquot of the urine were collected and kept in a refrigerator until the end of the collection period. The urine was acidified with hydrochloric acid and stored in closed glass containers. Each daily collection of feces was placed in an individual plastic bag with a small amount of toluene added to aid in preservation. After each collection trial the feces were oven-dried, ground, thoroughly mixed, and sampled. Each day a sample of each ration was collected to make a composite sample of each ration. Nitrogen content of each feed, feces, and urine sample was determined.

Biuret was determined in the feed and urine by the method of Pinckney (1949) modified as follows: (a) Use of double concentrations of glycerol and of copper sulfate in the biuret reagent, (b) readings were taken immediately after mixing the sample and reagent (the time at which the biuret in the sample gives maximum color with the copper reagent but the protein in the sample does not) and (c) use of versene to break up the copper-biuret complex after the first reading—thus a second reading could be taken and the contribution of reagent color and turbidity of the same samples could be assessed. Recovery trials indicated the suitability of these modifications for the estimation of biuret.

*Metabolism. Steers.* Six calves weighing approximately 425 lb. each were used in a 3 x 3 Latin square designed study (table 2). The calves were fed chopped prairie hay and a supplement containing either urea, biuret, or soybean meal as the main source of nitrogen. After 3 weeks on an

TABLE 1. THE EXPERIMENTAL DESIGN, NITROGEN INTAKE, APPARENT DIGESTION COEFFICIENT OF NITROGEN, AND NITROGEN BALANCE OF LAMBS FED THREE SOURCES OF NPN AT TWO LEVELS OF FEEDING TWICE DAILY [a]

| Lamb no. | Trial | Nitrogen intake | Apparent digestion coefficient of nitrogen | Nitrogen balance [b] |
|---|---|---|---|---|
| | | gm. | | gm. |
| | | | "Urea" ration | |
| 4290 | I | 12.6 | 76 | 1.3 |
| 4257 | | 12.6 | 76 | 1.5 |
| 4080 | II | 12.6 | 74 | —0.3 |
| 4194 [c] | | 12.6 | 75 | —2.1 |
| 4360 | III | 12.6 | 77 | 0.6 |
| 4150 | | 12.6 | 73 | 0.5 |
| Average | | | 75 | 0.25(2.6) |
| 4290 | IV | 18.9 | 75 | 3.3 |
| 4257 | | 18.9 | 74 | 2.5 |
| 4080 | V | 18.9 | 73 | 3.3 |
| 4194 | | 18.9 | 76 | 3.5 |
| 4360 | VI | 18.5 [d] | 77 | 2.7 |
| 4150 | | 16.2 [d] | 72 | 3.4 |
| Average | | | 74 | 3.12(22.8) |
| | | | "Urea-Biuret" ration | |
| 4290 | II | 12.0 | 71 | 1.1 |
| 4257 | | 12.0 | 66 | 0.9 |
| 4080 | III | 12.0 | 72 | 1.4 |
| 4194 [c] | | 12.0 | 77 | 0.8 |
| 4360 | I | 12.0 | 68 | 0.2 |
| 4150 | | 12.0 | 66 | 0.9 |
| Average | | | 70 | 0.88(10.5) |
| 4290 | V | 17.9 | 71 | 5.4 |
| 4257 | | 17.9 | 70 | 5.3 |
| 4080 | VI | 17.9 | 74 | 4.3 |
| 4194 | | 17.9 | 76 | 3.8 |
| 4360 | IV | 17.9 | 66 | 2.1 |
| 4150 | | 17.9 | 64 | 2.8 |
| Average | | | 70 | 3.95(31.6) |
| | | | "Biuret" ration | |
| 4290 | III | 11.3 | 65 | 4.0 |
| 4257 | | 11.3 | 60 | 3.0 |
| 4080 | I | 11.3 | 68 | 1.3 |
| 4194 [c] | | 9.0 [d] | 62 | 2.4 |
| 4360 | II | 11.3 | 58 | —0.3 |
| 4150 | | 11.3 | 61 | —0.3 |
| Average | | | 62 | 1.65(24.3) |
| 4290 | VI | 12.9 [d] | 72 | 4.2 |
| 4257 | | 15.4 [d] | 67 | 4.4 |
| 4080 | IV | 16.9 | 63 | 2.3 |
| 4194 | | 16.9 | 65 | 0.4 |
| 4360 | V | 16.3 [d] | 69 | 2.9 |
| 4150 | | 14.1 [d] | 64 | 3.0 |
| Average | | | 66 | 2.87(28.1) |

[a] Lambs were fed 300 gm. of ration twice daily during Trials I, II, and III, and 450 gm. twice daily during Trials IV, V, and VI.

[b] Nitrogen balance as a percent of apparently digested nitrogen is shown in parenthses.

[c] Lamb 4194 was used in the last five collection periods, replacing lamb 4117 which was used in Period I but failed to eat satisfactorily.

[d] Feed not consumed was weighed back.

made by adding 908 gm. of urea and 1,040 gm. of biuret to 100 lb. of the basal feed mixture; and, "biuret" ration made by adding 2,080 gm. of biuret to 100 lb. of the basal feed mixture.

The reversal technique was used so that on each level of feed intake each lamb received each ration sometime during the study. Each animal was randomly allotted to the first ration and thereafter received the rations according to the sequence in the design which is shown in table 1 with the results.

All animals were group-fed the basal feed mixture supplemented with 4% urea for a 19-day adjusting period prior to the first preliminary period. The lambs were individually and equally fed the test rations during the preliminary periods for each trial. Lambs on the lower level of feed intake were offered 300 gm. of one of the test rations twice daily. Lambs on the higher level of feed intake were offered 450 gm. of one of the test rations twice daily.

The length of the preliminary periods were: 18 days for Trial I, 11 days for Trial II, 10 days for Trial III, 7 days for Trial IV, and 4 days each for Trials V and VI. The later trials had to be shortened because of failure to receive biuret which was delayed in shipment.

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Biuret was determined in the feed and urine by the method of Pinckney (1949) modified as follows: (a) Use of double concentrations of glycerol and of copper sulfate in the biuret reagent, (b) readings were taken immediately after mixing the sample and reagent (the time at which the biuret in the sample gives maximum color with the copper reagent but the protein in the sample does not) and (c) use of versene to break up the copper-biuret complex after the first reading—thus a second reading could be taken and the contribution of reagent color and turbidity of the same samples could be assessed. Recovery trials indicated the suitability of these modifications for the estimation of biuret.

*Metabolism. Steers.* Six calves weighing approximately 425 lb. each were used in a 3 x 3 Latin square designed study (table 2). The calves were fed chopped prairie hay and a supplement containing either urea, biuret, or soybean meal as the main source of nitrogen. After 3 weeks on an

TABLE 2. EXPERIMENTAL DESIGN AND SOURCE OF ADDED NITROGEN IN THE NITROGEN METABOLISM STUDY WITH STEERS

| Steer no. | Nitrogen supplement [a] fed with chopped prairie hay | | |
|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 |
| 99 | Urea | Biuret | Soybean meal |
| 88 | Urea | Soybean meal | Biuret |
| 92 | Biuret | Soybean meal | Urea |
| 89 | Biuret | Urea | Soybean meal |
| 91 | Soybean meal | Urea | Biuret |
| 87 | Soybean meal | Biuret | Urea |

[a] See table 3.

adjusting ration of chopped prairie hay and urea-containing supplement, the steers were randomly allotted to one of the test rations designated as "urea", "biuret", or "soybean meal" rations. Each test ration was composed of 8.0 lb. of chopped prairie hay fed in two equal feedings of 4.0 lb. each daily and 2.2 lb. of one of the three supplements fed once daily. The composition of each supplement is shown in table 3.

Each trial consisted of a 10-day preliminary feeding period followed by a 7-day collection period. The steers were placed in wooden metabolism cages constructed for separate quantitative collection of the feces and urine. Each day 10% aliquots of urine were taken, acidified, and stored in closed containers, and refrigerated until the nitrogen analyses were made; and, 10% samples of the feces were taken, preserved with toluene, and stored in plastic bags, and refrigerated until they were dried, ground, and analyzed. A small sample of both the chopped hay and the supplement were taken each day to make a composite sample of the hay and a composite sample of the supplement used for each trial. Routine (A.O.A.C.) laboratory methods were used to determine the dry matter, nitrogen, ether extract,

TABLE 3. PERCENTAGE COMPOSITION OF SUPPLEMENTS FED WITH CHOPPED PRAIRIE HAY IN THE STEER METABOLISM STUDY

| Ingredient | Designation of the supplement | | |
|---|---|---|---|
| | "Urea" | "Biuret" | "Soybean meal" |
| Urea | 8.0 | .. | .. |
| Biuret | .. | 10.5 | .. |
| Soybean meal | 10 | 10 | 62 |
| Cerelose | 12.5 | 10 | .. |
| Starch | 31.5 | 31.5 | .. |
| Ground corn | 10 | 10 | 10 |
| Wheat bran | 10 | 10 | 10 |
| Alfalfa meal | 10 | 10 | 10 |
| Minerals and vitamin A and D supplement | 8 | 8 | 8 |

and crude fiber content of the feeds and feces. Nitrogen determinations were made on the urine samples.

*Growth and Reproduction. Sheep.* Two groups of five mixed wether and ewe lambs each averaging approximately 70 lb. were fed rations in which either urea or biuret furnished two-thirds of the 2% nitrogen in the rations. The lambs were kept in an open shed and individually self-fed the first 128 days and group self-fed 465 additional days. A fertile ram was put with the ewes in both lots for several weeks during the breeding season.

After 593 days on the first two rations, the nine surviving sheep were relotted into three lots of three each with two additional feeder lambs for each of the three lots the last phase of the study. Sheep in two of the three lots received either urea-supplemented or biuret-supplemented rations as fed prior to relotting, and the sheep in the third lot received the basal ration without supplemental urea or supplemental biuret. The composition of each ration is given in table 5. Weight increases, wool production, and the ability of the ewes to produce normal lambs were criteria used to compare the rations.

TABLE 5. COMPOSITION OF RATIONS FED FREE-CHOICE TO SHEEP IN THE GROWTH AND REPRODUCTION STUDY

| Ingredient | Ration | | |
|---|---|---|---|
| | Basal | Basal+Urea | Basal+Biuret |
| Ground corncobs | 23.8 | 23.8 | 23.8 |
| Ground corn | 38.8 | 38.8 | 38.8 |
| Starch | 23.8 | 23.8 | 23.8 |
| Molasses | 9.1 | 9.1 | 9.1 |
| Minerals | 3.6 | 3.6 | 3.6 |
| Wheat germ oil | 0.5 | 0.5 | 0.5 |
| Choline chloride | 0.1 | 0.1 | 0.1 |
| Urea | .. | 2.4 | .. |
| Biuret | .. | .. | 3.0 |
| A and D concentrate | + | + | + |
| Total parts | 99.7 | 102.1 | 102.7 |

The biuret used in the toxicity tests, metabolism studies, and the growth and reproduction study was essentially free of urea as determined by solubility tests and failure to react with urease.

## Results

*Toxicity Tests. Sheep.* In the first test the ewe readily consumed all of the biuret-fortified feed and appeared healthy and normal in every respect. There were no visible symptoms of toxicity or indications of unusual after-effects.

In the second test no abnormal reactions or symptoms of toxicity were exhibited by the ewes which received by drench 30, 60, and 90 gm. of biuret, respectively.

In the third test in which an overwhelming amount of biuret was administered by drench to lambs, symptoms of distress were apparent during the first 36 hours after drenching. There was an appreciable amount of material

TABLE 4. APPARENT DIGESTION COEFFICIENTS OF DRY MATTER, NITROGEN, ETHER EXTRACT, CRUDE FIBER, NITROGEN-FREE EXTRACT, AND NITROGEN BALANCE IN THE STEER METABOLISM STUDY

| Item | Digestion coefficients | | | | | |
|---|---|---|---|---|---|---|
| | Dry matter | Nitrogen | Ether extract | Crude fiber | Nitrogen free extract | Nitrogen balance[a] |
| | | | | | | % |
| Steer no. | | | Average for steers | | | |
| 87 | 60.1 | 62.7 | 35.1 | 62.6 | 64.5 | 48.4 |
| 88 | 62.0 | 64.7 | 41.5 | 64.1 | 66.4 | 38.0* |
| 89 | 61.8 | 66.9 | 35.2 | 62.7 | 66.3 | 45.8 |
| 91 | 59.5 | 64.1 | 33.3 | 61.2 | 64.3 | 42.6 |
| 92 | 60.8 | 64.1 | 40.3 | 63.1 | 64.9 | 54.3 |
| 99 | 61.2 | 63.7 | 41.0 | 62.8 | 65.7 | 51.7 |
| Period | | | Average for periods | | | |
| 1 | 61.0 | 63.8 | 42.8 | 63.4 | 65.8 | 45.8 |
| 2 | 61.7 | 64.9 | 41.8 | 63.1 | 65.9 | 46.2 |
| 3 | 60.0 | 64.5 | 28.7** | 61.8 | 64.4 | 48.3 |
| Treatment | | | Average for treatments | | | |
| Urea | 60.2 | 66.2 | 36.8 | 61.4 | 64.4 | 48.8 |
| Biuret | 60.1 | 62.0** | 37.1 | 60.8 | 65.4 | 42.3* |
| Soybean meal | 62.4 | 65.0 | 39.3 | 66.1** | 66.2 | 49.1 |

[a] As percent of apparently digested nitrogen.
* $P<0.05$.
** $P<0.01$.

which apparently had crystallized out of the urine and collected on the hairs of the prepuce of the lamb which received 275 gm. of biuret. Subsequent chemical analysis showed the material contained 82% biuret reacting material. Five days later both lambs were eating well and acting normally. The internal organs appeared to be normal upon clinical examination when the lambs were slaughtered 3 months later.

*Metabolism. Lambs.* Table 1 shows the sequence of the treatments and the nitrogen balance data. These values were tested statistically by analysis of variance.

On the lower level of feed intake, the apparent digestion coefficient for nitrogen was significantly lower ($P<0.01$) for the "biuret" ration than

for the other two rations, and the nitrogen balance was significantly higher ($P<0.05$) for the "biuret" ration than for the "urea" ration.

On the higher level of feed intake, the average apparent digestion coefficient for nitrogen was highest for the "urea" ration and lowest for the "biuret" ration with the "urea-biuret" ration having an intermediate value. These averages were significantly ($P<0.01$) different from each other. The nitrogen balance for the "biuret" ration was significantly lower ($P<0.05$) than the "urea-biuret" ration but only slightly lower than the "urea" ration.

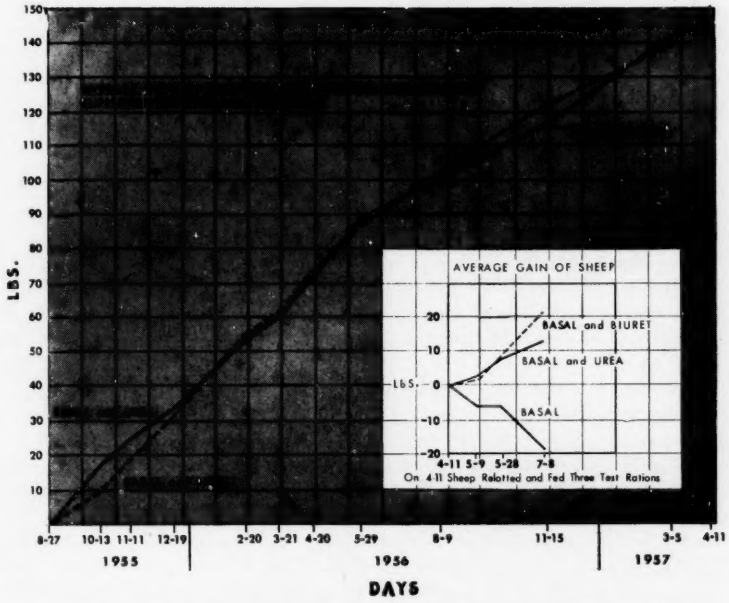


**Figure 1. Performance of sheep in the growth and reproduction study.**

Most of the lambs on the low level of feed intake consumed their feed in a relatively short period of time while most of the lambs on the higher level of feed intake required several hours to completely clean up all feed offered (approaching self-feeding).

The urine of the biuret-fed lambs contained four times as much biuret-reacting material as the urine of the urea-fed lambs. This amounted to 27% and 49%, respectively, of the biuret intake of the lambs fed the "biuret" ration and the "urea-biuret" ration.

*Metabolism. Steers.* Results are shown in table 4. The digestion coeffi-

cient for nitrogen was significantly lower ($P<0.01$) for the "biuret" rations than for the "urea" and the "soybean meal" rations. Nitrogen balance as a percent of the apparently digested nitrogen was significantly lower ($P<0.05$) in the steers receiving the "biuret" ration. The apparent digestibility of the crude fiber was significantly higher ($P<0.01$) for the "soybean meal" ration.

The urea-supplement and the biuret-supplement were consumed at a slower rate than soybean meal-supplement.

*Growth and Reproduction. Sheep.* Growth as measured by body weight increase (figure I) was satisfactory on both the urea-supplemented and the biuret-supplemented rations which were self-fed for 593 days. The average gain for the period, including the weight of the wool shorn, was 150.9 lb. per sheep on the urea-supplemented ration and 150.2 lb. per sheep on the biuret-supplemented ration. The average grease weights of the fleeces for the first and second year, respectively, were 9.3 lb. and 8.0 lb. for sheep on the urea-supplemented ration and 9.6 lb. and 9.7 lb. for sheep on the biuret-supplemented ration.

Some sheep in each lot pulled and ate wool from the other sheep in the same lot. This abnormal appetite was more noticeable in the sheep in the lot receiving the basal ration without either supplemental urea or supplemental biuret. One sheep was lost in the lot receiving the urea-supplemented ration after 17 months of feeding. The cause of death was not definitely determined although urea toxicity was suspected as it was believed that the sheep had overeaten the ration after a few hours of interruption in self-feeding.

After relotting to three treatments during the last phase of the study, the sheep on the urea-supplemented and biuret-supplemented rations continued to gain satisfactorily while sheep on the basal ration lost weight.

Ewes in lots receiving either the urea-supplemented or the biuret-supplemented rations gave birth to lambs which appeared normal, and the ewes lactated sufficiently to promote normal growth in the lambs.

## *Discussion*

The survival and general appearance of the animals after the critical toxicity tests as well as performances on the metabolism studies and growth and reproduction study indicated that biuret was neither acutely nor cumulative toxic. Reports of less severe treatments by Meiske *et al.* (1955), Repp *et al.* (1955), Berry *et al.* (1956) are in substantial agreement that the toxicity of biuret for ruminants is low. The work of Dinning *et al.* (1948), Repp *et al.* (1955) would suggest that levels of urea similar to those of biuret used would have been extremely hazardous. These data suggest that it is unlikely that biuret would be toxic when used in ruminant feeds at levels to supply a significant part of the nitrogen requirements.

The positive nitrogen balances in the metabolism studies were evidence of utilization of the nitrogen in the ration. It is highly improbable that there was sufficient non-biuret nitrogen available for metabolism and the positive nitrogen balance in the biuret rations. Meiske *et al.* (1955) obtained significantly increased daily gains and feed efficiencies when a low nitrogen basal ration was supplemented with biuret, crude biuret, or urea.

In the metabolism study with lambs, at the lower level of feed intake, the animals receiving the "biuret" ration retained significantly more nitrogen than the animals receiving the "urea" ration. At the higher level of feed intake, where the consumption was more continuous the lambs receiving the "urea-biuret" ration bad the highest average nitrogen balance. This finding tends to support the hypothesis that a mixture of urea (which releases its nitrogen quickly under the influence of the urease activity of the rumen) and biuret (which is not so soluble) might be a better source of NPN for ruminants than either urea alone or biuret alone.

Differences in the nitrogen intake and/or the nitrogen utilization may have affected the nitrogen balances with lambs; however, it should be noted that the percent of apparently digested nitrogen which was retained (balance) was higher in lambs on the "biuret" ration than in lambs on the "urea" ration at both levels of feed intake.

For steers, apparently the "soybean meal" and "urea" rations were superior to the "biuret" ration in terms of nitrogen digestibility and utilization.

Welch *et al.* (1956) found that feeding crude biuret significantly depressed the apparent digestibility of nitrogen.

Figure 1 shows that the average gains of the sheep receiving the urea-supplemented rations and the sheep receiving the biuret-supplemented rations were good and almost identical at the end of 593 days. However, average gains by the sheep fed the "biuret" rations were slightly less than average gains by sheep fed the "urea" rations for the first three weigh periods. This slight lag in gains may have been partially due to a slower adaptation of the rumen flora to the imposed environment than was the case on the "urea" ration. Small amounts of urea in the saliva probably promote and maintain a sufficiently large part of the "normal" rumen flora to allow quick adaptation for utilizing larger concentrations of urea. However, a longer period of time may be required for the "normal" rumen flora in animals which had not been previously fed biuret nitrogen to adjust to a biuret-containing feed than to adjust to higher concentrations of urea. Welch *et al.* (1957) found that the nitrogen utilization by lambs on semi-purified rations was improved by increasing the length of the preliminary feeding. Ewan *et al.* (1958) have clearly demonstrated the effect of inoculation on biuret nitrogen utilization. Significantly increased nitrogen balances in lambs fed biuret-supplemented rations were obtained when the lambs were inoculated (by drench) with rumen liquor from sheep maintained on biuret-containing feed as compared with lambs that were fed

the same rations but inoculated with rumen liquor from sheep maintained on urea-containing feed.

Fence chewing and wool pulling observed in the growth and reproduction study indicated some abnormality of appetite which seems to be a factor with lambs on almost all semi-purified diets used at this Station. This seeming inadequacy may be due to the physical form, minerals, or factors other than nitrogen. If it was due to the source of nitrogen there appeared to be no difference between urea-fed and biuret-fed sheep.

Since urea decomposes to biuret when heated, it is likely that much of the urea-containing pelleted feeds used in livestock feeding contain some biuret. Jones (1954) found some biuret reacting material in pelleted urea.

## Summary

A series of studies on the toxicity and nitrogen utilization of biuret as a source of NPN for sheep and cattle is reported. Critical toxicity tests were conducted with sheep. Metabolism studies were conducted with sheep and cattle. A growth and reproduction study with sheep was conducted over a period of 593 days. The following general conclusions are drawn:

1. Biuret fed at levels to supply a significant part of the nitrogen requirements was neither acutely nor cumulatively toxic to sheep. Growth, reproduction, and wool production did not seem to be adversely affected when sheep were fed biuret-containing rations.

2. Positive nitrogen balances were obtained with sheep and steers fed rations in which biuret nitrogen furnished a major part of the total nitrogen intake.

3. Satisfactory growth and reproduction were obtained in sheep fed low nitrogen rations supplemented with biuret.

4. The utilization of biuret nitrogen in comparison with urea nitrogen appeared to be influenced by level of feed intake.

5. These results indicate that biuret can be used to increase the flexibility of NPN use in ruminant rations.

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# SEPARATE COLLECTION OF FECES AND URINE OF COWS

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IN balance trials with cows quantitative, separate collection of feces and urine is an important but difficult affair. As a rule a rubber urinal is used attached to the cow by means of some type of harness. Hobbs *et al.* (1950) did without a harness by sticking short straps to the cow to bear the urinal. Cunningham *et al.* (1955) used a catheter to collect the urine.

For energy metabolism experiments we think catheterizing a somewhat abnormal and dangerous method. When we used a urinal after Möllgaard (1929) fairly similar to the one of Forbes *et al.* (1937) the sticking method failed, perhaps because the urinal and the urine conduit weighed too much. Another method with a net around back and sides of the animal to hold the straps and cords of the urinal gave good results only with some cows. It required frequent supervision and rearranging which was very time-consuming. After replacing the net by a leather harness, similar to the canvas one of Möllgaard (1929) results were better, but again not with all cows. The addition of cords going between the hind legs of the animal from the lower rings of the urinal to straps under the belly was tried. These cords which are often used (Putnam *et al.*, 1956; Gorski *et al.*, 1957; de Groot *et al.*, 1937) injured the skin within a few days and had to be discarded. Especially cows that curved their back very much while urinating gave a lot of trouble. We tried to utilize this habit of many cows. Two inflexible rods were connected to the iron rings of the right and left side of the urinal (figure 1). The lower ends of the rods were connected to the harness on the back between the hipbones with cords that went through an iron ring of the harness above the hip joint. When the cow curved its back the lower rim of the urinal was pressed by these cords tightly against the skin. Another pair of cords going from the upper end of the rods through rings between the hipbones and the pinbones to the straps under the belly were needed to prevent the upper rim of the urinal coming free from the skin. When the back was straight both pairs of cords were almost loose and only the rubber straps coming from the straps under the belly and going through leather loops of the harness kept the urinal in position. We have used harness and urinal in this way in 20 collection periods of 14 days each with 15 different cows with good results, though with some animals incomplete success has been obtained. It requires 2 or 3 days before the correct position of the urinal and the optimal tightness of the cords are

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known. After that, inspection twice-a-day is enough. Special attention must be given to worn straps and cords.

More recently with the same harness we tested a urinal, described by Richter and Becker (1952), and another constructed after our design in Holland. The former is bigger than the urinal of Möllgaard and without a metal frame; it must be pressed to the cow by a leather ring, an additional part of the harness. Instead of this ring we used an iron frame partly covered with leather (figure 2) and connected this frame to the harness in the same way as we did with the Danish urinal. The Dutch

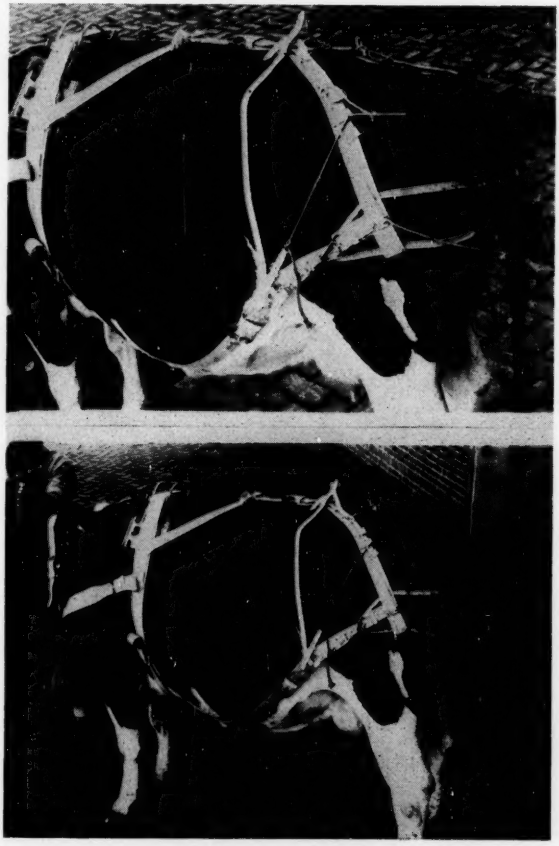

**Figure 1. Top. Harness with Danish urinal.**
**Figure 2. Bottom. Harness with German urinal.**

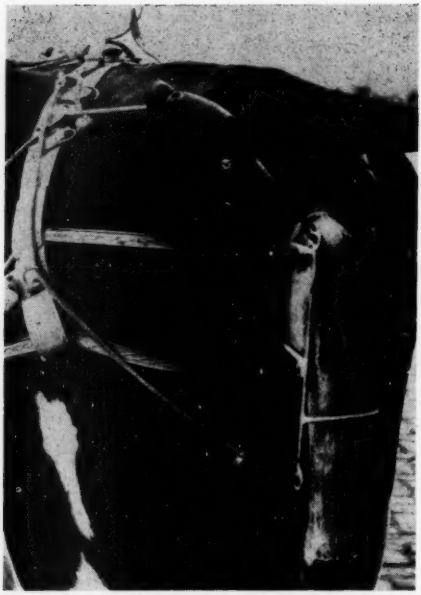

**Figure 3. Harness with Dutch urinal.**

urinal (figure 3) is a modification of the Danish one having a bigger size, thicker rubber and an iron frame adapted to our method of attaching it to the harness. With both types even better results were obtained than with the Danish urinal. With cows of 500 kg. and more, a urinal of a size bigger than that of Möllgaard's is indeed to be preferred.

**Figure 4. German, Dutch and Danish urinals.**

## Summary

A description is given of a modified harness and urinal used for separate collection of urine and feces of cows during long metabolism experiments.

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# THYROPROTEIN FOR LACTATING SOWS [1, 2]

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MANY attempts have been made to improve baby pig performance by supplementation of the sow's ration to increase quantity or quality of milk immediately following parturition. The use of hormones to reach this goal in swine has been quite limited, but numerous reports have appeared relating to other species. Reineke and McMillen (1946) reported that a low level of thyroprotein fed to sows did not improve the weaning weight of their pigs, but stimulated milk flow in poor-milking sows. Muller and Zenisek (1955) reported that thyroprotein supplementation of sow rations (2–4 gm./day) increased pig weaning weights; they also reported similar results in experiments with the rat.

Robinson (1947, 1947a) reported that the failure of mothers to establish lactation in puerperium was due to a deficiency in the production of thyroxine by the thyroid gland. Romani (1951) showed that women with hypoglactia responded to 1.5 mg. of synthetic thyroxine or less given daily with no unfavorable side-effects on either the mother or child. He stated that early treatment was more effective than when lactation failed during the first 2 months. Neumann *et al.* (1950) and Labban (1957) demonstrated that iodinated casein and thyroxine increased milk production in sheep. Leech and Bailey (1953), in field tests with 2000 cows, reported a marked increase in milk production during treatment with either L-thyroxine or iodinated casein. Thomas *et al.* (1954, 1957) reported an increase of about 20% in milk production by cows during a 60-day test period. Owen and Darrock (1957) showed that thyrotropin, administered by subcutaneous injection, would increase the quantity of milk produced by goats.

The objectives of these experiments were (1) the effect of thyroprotein on early pig gain and livability and on milk composition, (2) the effect of withdrawal of thyroprotein, (3) the weight changes in the lactating sow to 4 days postweaning, and (4) the effect of different systems of feeding thyroprotein.

## Procedure

The following management practices were similar for all experiments except where indicated. On the 110th day of gestation, the sows were placed

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[3] This paper is part of a thesis submitted by the senior author to the Graduate College, Iowa State College, in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Animal Nutrition.

[4] Department of Animal Husbandry.

in farrowing stalls and randomly allotted to the ration treatments according to breeding date. The sows were fed 6 lb. daily of their respective ration until farrowing. The composition of the basal ration is presented in table 1. Immediately after farrowing all sows were individually full-fed in their farrowing stall. The sows that nursed pigs to 5 weeks were moved to individual pens 1 week after farrowing and were self-fed. All animals had free access to fresh water.

The baby pigs were individually marked and weighed before they were 24 hours old. Weights were recorded to the nearest 0.1 lb., and pigs that

TABLE 1. COMPOSITION OF EXPERIMENTAL CONTROL RATION

| Ingredients | Pounds |
|---|---|
| Yellow corn (ground) | 40.05 |
| Oats (ground) | 20.00 |
| Meat and bone scraps | 5.00 |
| Beet pulp (dried and ground) | 5.00 |
| Solvent soybean oil meal (44% protein) [a] | 10.00 |
| Dried whey (70% lactose) | 5.00 |
| Dehydrated alfalfa meal | 10.00 |
| Condensed fish solubles | 2.50 |
| Dicalcium phosphate (26% Ca, 18% P) | 0.50 |
| Salt (iodized) | 0.50 |
| Trace mineral premix [b] | 0.20 |
| Vitamin-antibiotic premix [c] | 1.25 |
| Total | 100.00 |

[a] Solvent soybean oil meal (50% protein) was used in Exp. III and IV.
[b] Contributed per pound of ration; Fe, 64 mg.; Cu, 4.4 mg.; Co, 1.42 mg.; Zn, 74.2 mg.; Mn, 51.6 mg.; K, 6.8 mg.
[c] Contributed per pound of ration; vitamin $D_2$, 500 I.U.; riboflavin, 1 mg.; pantothenic acid, 5 mg.; niacin, 13 mg.; choline, 30 mg.; vitamin $B_{12}$, 10 mcg.; penicillin, 10 mg. (In Exp. IV, 25 mg. per lb. chlortetracycline replaced the penicillin.)

weighed less than 2.0 lb. at birth were sacrificed. Thereafter all pigs were individually weighed weekly. All pigs were given an anemia preventative treatment.

The data were statistically analyzed by analysis of variance procedures for completely random designs as described by Snedecor (1956).

## Experimental

*Experiment I.* Trial A, involving 32 litters was conducted during the summer of 1955 to study the effect of levels of thyroprotein (0, 50, 100 and 200 mg./lb. ration) on first week pig gains. The pigs nursing the sows receiving the ration supplemented with 100 mg. of thyroprotein gained more than the pigs nursing the sows on the control ration while the levels of 50 and 200 mg. per lb. had no appreciable effect on first week pig gain (table 2). The 200-mg. level increased the rectal temperature and respira-

TABLE 2. EXP. I, LEVELS OF THYROPROTEIN FOR LACTATING SOWS (TRIAL A)

| | Levels of thyroprotein (mg./lb. ration) | | | |
|---|---|---|---|---|
| | 0 | 50 | 100 | 200 |
| Litters, no. | 8 | 8 | 8 | 8 |
| Live pigs farrowed per litter, no.[a] | 9.75 | 9.00 | 7.37 | 8.75 |
| Pigs weaned per litter, no. | 8.50 | 8.38 | 7.12 | 8.50 |
| Pig mortality per litter, no. | 1.25 | 0.62 | 0.25 | 0.25 |
| Birth wt. of pigs weaned, lb. | 2.96 | 2.98 | 3.14 | 3.02 |
| First week gain per pig, lb. | 2.08 | 1.84 | 2.55 | 2.01 |
| First week litter gain, lb. | 17.52 | 15.68 | 17.63 | 17.21 |
| Sow rectal temperature, °F | 102.8 | 102.4 | 102.7 | 103.7 |
| Sow respiration rate, per min. | 78.5 | 76.5 | 70.2 | 94.1 |

[a] Pigs weighing less than 2 lb. at birth were sacrificed.

tion rate; however, the other levels tested had little or no effect on these metabolic measurements.

Trial B (30 litters) and trial C (30 litters) were conducted during the same summer and following winter to compare the control ration with what appeared to be the optimum level of thyroprotein supplementation in the first trial (100 mg. per lb.).

The data for the three trials for the control ration and the 100-mg. level of thyroprotein are combined in table 3. The pigs nursing the sows fed the thyroprotein supplemented ration showed an increase in first week pig gain in both mature sow litters (2.77 vs. 2.14 lb.) and in first litter sow litters (2.55 vs. 2.06 lb.). Pig mortality was reduced on the thyroprotein supplemented ration 0.30 and 0.26 pig per litter on mature and first litter sows, respectively.

TABLE 3. EXP. I. RESULTS OF FEEDING THYROPROTEIN (100 MG./LB. RATION) TO SOWS DURING FIRST WEEK OF LACTATION (TRIALS A, B AND C COMBINED)

| | Mature sows | | First litter sows | |
|---|---|---|---|---|
| Item | Control | Thyro-protein | Control | Thyro-protein |
| Litters, no. | 17 | 17 | 20 | 22 |
| Live pigs per litter first day, no.[a] | 9.70 | 8.70 | 8.90 | 8.30 |
| Pigs weaned per litter, no.[b] | 9.06 | 8.30 | 8.55 | 8.00 |
| Pig mortality per litter, no. | 0.60 | 0.30 | 0.40 | 0.14 |
| Birth wt. of pigs weaned, lb.[c] | 2.89 | 2.90 | 3.11 | 3.05 |
| First-week gain per pig, lb.[d] | 2.14 | 2.77 | 2.06 | 2.55 |
| Feed consumed per sow, first week, lb. | 47.9 | 47.8 | 53.3 | 50.4 |

[a] All pigs weighing less than 2 lb. at birth were sacrificed.
[b] Correlation coefficient for pigs per litter and gain = −.35.
[c] Correlation coefficient for pig birth weight and gain = 0.33.
[d] Difference in first week pig gain between controls and thyroprotein supplemented groups was statistically significant (P = 0.05 or less).

Determination of the solids content of milk from 14 mature and 16 first litter sows in trial C indicated no apparent differences in milk fat, non-fat milk solids or total solids that could be attributed to ration treatment.

*In Experiment II,* (field test) the 135 sows were self-fed a pelleted ration containing either no supplemental thyroprotein or 100 mg. of thyroprotein per pound of ration. They were kept in the farrowing stall from farrowing to weaning. Other management practices were similar to those of previous experiments except that pigs which weighed less than 2 lb. at birth were

TABLE 4. EXP. II. RESULTS OF THYROPROTEIN SUPPLEMENTATION OF SOW RATIONS (100 MG./LB.) ON GAINS AND LIVABILITY OF NURSING PIGS (FIELD TEST)

| Item | Trial D[a] | | Trial E[b] | |
|---|---|---|---|---|
| | Basal | Thyro-protein | Basal | Thyro-protein |
| Litters, no. | 30 | 27 | 30 | 28 |
| Live pigs farrowed per litter, no. | 8.13 | 8.22 | 8.00 | 8.00 |
| Pigs weaned per litter, no. | 6.70 | 7.33 | 7.00 | 7.36 |
| Pig mortality per litter, no. | 1.43 | 0.89 | 1.00 | 0.64 |
| Av. birth wt. of pigs weaned, lb. | 2.66 | 2.78 | 2.87 | 2.73 |
| Av. pig gain: | | | | |
| Birth to 7 days, lb. | 1.90 | 2.41 | 2.67 | 2.65 |
| Birth to 14 days, lb.[c] | 4.73 | 5.44 | 5.99 | 6.07 |
| Birth to 21 days, lb. | .... | .... | 9.10 | 9.71 |
| Total litter gain, lb. | 31.96 | 39.88 | 63.70 | 71.47 |

[a] Trial D—pig weaned at 2 weeks of age. Nine first-litter sows per group; other were mature sows.
[b] Trial E—pigs weaned at 3 weeks of age. Two first-litter sows per treatment; others were mature sows.
[c] Difference in pigs gains in trial D statistically significant (P=0.05 or less).

not sacrified. The pigs nursing the sows fed the ration supplemented with 100 mg. per lb. of thyroprotein were heavier when weaned at 2 weeks of age (table 4, trial D, gain, 5.44 vs. 4.73 lb.) or when weaned at 3 weeks of age (trial E, gain, 9.71 vs. 9.10 lb.). The pig mortality in the litters nursing the sows fed the thyroprotein supplemented rations was reduced an average of 0.54 and 0.36 pig per litter for the two trials, D and E, respectively.

*Experiment III,* was designed to study the effect of the withdrawal of thyroprotein on the seventh day of lactation and also the sow weight changes during a five-week lactation and a four-day post weaning period. Sixteen sows were divided into two groups and eight of them were fed the control diet starting on the 110th day of gestation and the other eight received the ration containing 100 mg. supplemental thyroprotein per lb. of ration. When the pigs were 7 days of age, four of the sows of each group were changed to the other diets. The sows and litters were transferred from

farrowing stalls to individual pens on the seventh day post partum. The pigs were not fed a creep ration. The pigs nursing the sows from which the thyroprotein ration was withdrawn on the seventh day gained more during the first week than any of the other three groups, but the following week after withdrawal there was a marked decrease in pig gain with some improvement in pig gain the third week (figure 1). The pigs nursing sows fed thyroprotein from 0 to 35 days post partum were 1.80 lb. heavier than the controls at weaning. There was little if any difference in sow feed consumption due to ration treatment.

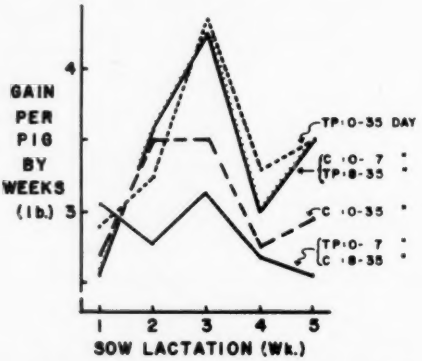


**Figure 1. Experiment III. Effect of withdrawal or addition of thyroprotein (TP) to sow ration on pig gain (C=control ration).**

In this experiment (III) the sows on the control ration lost an average of 18 lb. and those on the thyroprotein supplemented ration lost an average of 28 lb., from 3 to 35 days post partum (table 5). In an attempt to study the nature of the weight losses during the nursing period all sows had free access to water and were individually fed 1.25 lb. whole oats per 100 lb. body weight for 3 days after weaning. On the fourth day they were weighed after a 24-hr. feed shrink. The eight sows fed the thyroprotein supplemented ration from 0 to 35 and 7 to 35 days post partum lost 12 lb. less after weaning than the eight sows fed the control ration during the same periods. This difference in weight change after weaning was statistically significant ($P<0.05$).

Fifteen of the 16 sows in Experiment III were bred on the first heat period after weaning and fed during gestation on a corn silage and supplement ration. One sow fed the control ration during lactation had not come into estrus 60 days after farrowing. The sows fed thyroprotein during the greater part or all of lactation came into estrus in a fewer number of days

after weaning than the control sows, excluding the one sow mentioned above. In the subsequent farrowing, the control sows farrowed 10.5 pigs per litter with an average birth weight of 3.1 lb., and the treated sows farrowed 8.6 pigs per litter with an average birth weight of 3.5 lb.

*Experiment IV* was designed to study the effect of (1) feeding 1.0 gram of thyroprotein per day per sow for 3 days after farrowing, (2) feeding

TABLE 5. EXP. III. THE EFFECT OF THYROPROTEIN SUPPLEMENTATION OF LACTATION RATION ON PIG GAINS AND SOW PERFORMANCE (5-WEEK LACTATION)

| 110-day gestation to 7-day post partum<br>8 to 35 days past partum | Thyroprotein<br>Thyroprotein | Basal<br>Thyroprotein | Thyroprotein<br>Basal | Basal<br>Basal |
|---|---|---|---|---|
| Litters, no.[a] | 4 | 4 | 4 | 4 |
| Sow wt. 110-day gestation, lb. | 488.0 | 501.0 | 505.5 | 495.3 |
| Farrowing wt. loss, lb. | 49.0 | 31.0 | 38.0 | 33.3 |
| Litter wt. (all pigs), lb. | 33.7 | 24.4 | 33.8 | 25.9 |
| Pigs nursing sow first day | 9.25 | 8.75 | 10.25 | 8.75 |
| Pigs weaned per sow[b] | 9.00 | 6.75 | 9.25 | 8.50 |
| Birth wt., (pigs weaned) lb. | 3.26 | 2.99 | 2.97 | 2.64 |
| Pig gain to 35 days, lb. | 17.43 | 16.98 | 14.33 | 15.63 |
| Total litter gain, lb. | 156.1 | 115.2 | 133.7 | 133.6 |
| Sow nursing loss, lb. | 28.0 | 30.5 | 25.8 | 18.3 |
| Sow wt. loss post-weaning, lb. | 36.5 | 36.5 | 50.3 | 47.3 |
| Sow nursing and weaning wt. loss, lb. | 64.5 | 67.0 | 76.0 | 65.5 |
| Feed consumed per sow, lb. | 608 | 528 | 544 | 618 |

[a] Includes one first and three second-litter sows per treatment.
[b] Deaths occurred during the first 10 days.

thyroprotein at the rate of 100 mg. per lb. of ration from the 110th day of gestation to weaning of the pigs and (3) feeding of the ration containing thyroprotein from immediately after farrowing to time of weaning the pigs at 2 weeks of age. When 1.0 gram of thyroprotein was fed daily per sow the first 3 days after farrowing and then withdrawn, the average first week pig gain was less than in the control litters (2.17 lb. vs. 2.46 lb.). The average second week pig gains of the above two groups were almost identical (2.87 lb. vs. 2.96 lb.). When thyroprotein supplementation was started on the 110th day of gestation or immediately after farrowing there was an increase in pig gain over the pigs nursing the control sows for both the first and second week. There was no advantage gained by starting the feeding of thyroprotein before farrowing as both first and second week pig gains were slightly greater when the treatment was started immediately after farrowing.

Milk samples were taken from 10 sows on the control ration and 10 on the thyroprotein ration to study the influence of thyroprotein on the milk alkaline phosphatase activity. After the initial samples were taken

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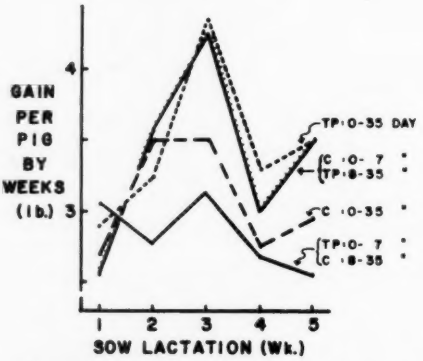


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Milk samples were taken from 10 sows on the control ration and 10 on the thyroprotein ration to study the influence of thyroprotein on the milk alkaline phosphatase activity. After the initial samples were taken

the rations were interchanged and samples again taken after a 4-day adjustment period. There was a large variation in the alkaline phosphatase of milk from individual udder sections, the standard deviation reaching as high as 94%. The average milk alkaline phosphatase on the 14th day post partum from the 10 control sows was 8.84 (±7.74) mcg. phosphorus released per ml. milk per hour,[5] and from the 10 sows fed thyroprotein it was 7.22 (±5.78). The correlation between milk alkaline phosphatase and 2-week pig gain was —.38. When the sows on the control ration were changed on the 14th day post partum to the thyroprotein supplemented

TABLE 6. EXP. IV. THE EFFECT ON PIG GAIN AND SOW PERFORMANCE FROM SUPPLEMENTATION WITH 100 MG. THYROPROTEIN PER POUND OF RATION

| Item | Basal | Thyroprotein |
|---|---|---|
| Litters, no. | 20 | 30 |
| Pigs nursing first day, no. | 9.60 | 9.47 |
| Pigs weaned, 2 wk., no. | 8.60 | 8.80 |
| Pig mortality per litter, no. | 1.00 | 0.57 |
| Birth wt. of pigs weaned, lb. | 2.83 | 2.98 |
| Pig gain 0–14 days, lb.[a] | 5.30 | 6.15 |
| Total litter gain, lb. | 45.75 | 54.11 |
| Sow wt. 110-day gestation, lb. | 441 | 487 |
| Sow farrowing loss, lb. | 27 | 31 |
| Sow nursing loss, lb. | 20 | 32 |
| Feed consumed per sow, lb. | 162 | 164 |

[a] Differences in pig gains between basal and thyroprotein-supplemented litters statistically significant (P=0.05 or less).

ration, the milk alkaline phosphatase decreased in six of the sows, remained constant in one sow, and increased in three sows. However, when the opposite crossover was made, where the sows on the thyroprotein ration were changed to the control ration, the milk alkaline phosphatase increased in all 10 sows.

The combined data for the 50 sows and litters of Experiment IV (excluding the 10 sows receiving thyroprotein the first 3 days post partum only) show that the pigs nursing the sows fed the thyroprotein supplemented ration outgained their controls by 0.45 lb. the first week and 0.40 lb. the second week for a total 2-week increase of 0.85 lb. or 16%. This increase in pig gain was statistically significant ($P<.01$). There was an average decrease of 0.43 pig per litter that died during the 2-week period and an average increase of 8.36 lb. in total litter gain. The sows fed thyroprotein lost 12 lb. more weight during the nursing period which was statistically significant ($P<.01$; table 6).

[5] Milk alkaline phosphatase determined by modification of the procedure described in Sigma Technical Bulletin No. 104, Sigma Chemical Co., 3500 Dekalb Street, St. Louis 18, Missouri.

*Discussion*

The addition of the optimum level of thyroprotein in this test, 100 mg. per lb. of ration, resulted in heavier weaning weights of pigs weaned at 1, 2, 3 and 5 weeks of age. The increases in pig gains were statistically significant ($P<.05$) in experiments when pigs were weaned at 1 (Exp. I) and 2 (Exp. II and IV) weeks of age, and approached significance ($P<.10$) when the pigs were weaned at 3 weeks of age (Exp. II). The pigs weaned at 5 weeks of age (Exp. III) gained 1.80 lb. more than their controls; the increased gain observed in this series of experiments, probably the result of increased milk secretion, was accompanied by an average decrease of 0.32 pig per litter in pig mortality.

Top-dressing the ration with 1 gram thyroprotein per day the first 3 days after farrowing appeared to depress first week pig gain (Exp. IV). The withdrawal of thyroprotein on the seventh day resulted in a sharp drop in second week pig gain (Exp. III); this was probably due to the effect of the exogenous source of thyroid hormone having suppressed the thyroid gland, then upon withdrawal several days were required for the secretory activity of the gland to return to normal. These findings are similar to those observed in the dairy cow (Swanson, 1954).

Sows fed a thyroprotein-supplemented ration during lactation lost 12 lb. (Exp. III and Exp. IV) more weight during the nursing period than those fed the control ration. However, the sows fed the thyroprotein supplemented ration (Exp. III) lost 12 lb. less weight during a 4-day post-weaning period. These shifts in weight may have been the result of increased water elimination (Turner, 1955) due to thyroprotein. If this post-weaning weight change was a true difference, and not due to a shift in body fluids, then there was little difference due to treatment in total weight changes from 3 days post-partum to 4 days post-weaning. These body weight changes are similar but less marked than those reported by Dudley *et al.* (1956). This difference in results can be partially explained on the basis of the type of ration fed and the length of the lactation period. In the experiments reported herein a high energy ration was fed and the pigs were weaned at a maximum of 5 weeks of age; whereas in the work cited above a ration of a lower energy content was fed and the pigs were weaned at 6 weeks of age. These workers also observed an improvement in pig gains from thyroprotein supplementation of the sow's ration.

## Summary

Four experiments involving 283 litters were conducted to study the effect of thyroprotein on the milk production of sows as measured by nursing pig gains. Of the levels of thyroprotein tested (0, 50, 100 and 200 mg. per lb. of ration fed *ad libitum*) the 100-mg. level produced an increase ($P<0.01$) in gain of 0.56 lb. during the first week; this level did not affect the sows' heart rate, rectal temperature, respiration rate or feed

consumption. The 50- and 200-mg. levels did not improve pig gains; the 200-mg. level increased rectal temperature and respiration rate.

Pigs nursing sows fed thyroprotein (100 mg./lb. of ration) gained more than the controls when weaned at 1, 2, 3 or 5 weeks of age. The increase in pig gains was accompanied by an average decrease in pig mortality of 0.32 pig per litter. Thyroprotein fed at the rate of 1.0 gram per day for the first three days after farrowing resulted in a depression in first week gains. Also, the withdrawal of thyroprotein on the 7th day post partum depressed pig gains during the subsequent week. There was no observed difference in the response whether thyroprotein supplementation started on the 110th day of gestation or at time of farrowing.

Sows fed thyroprotein lost an average of 5 lb. more weight from the 110th day of gestation to the 3rd day post partum, and 12 lb. more during a five-week nursing period than did their controls.

Analysis of milk samples did not show a difference in percent fat, solids, non-fat solids or alkaline phosphatase activity which could be attributed to ration treatment.

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# EVALUATION OF ALFALFA HAY BY CHEMICAL ANALYSES

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HAY is one of the most variable of the harvested livestock feeds. Not only does this variation create problems in formulating balanced rations, but it is of great concern where a large proportion of the hay is marketed. Hay quality and variability have long been judged by visual methods. These methods, while useful, have created problems for the livestockman who desires a consistent high quality product and for the alfalfa grower who deserves a premium for producing high quality hay. An example of the variability that can be found between hay samples visually judged to be equivalent is shown in table 1. Note that all of these hays

TABLE 1. COMPOSITION OF SOME ALFALFA HAYS SOLD ON THE LOS ANGELES MARKET [a]

| Hay | Federal grade | Water | Protein [b] | Ash [b] |
|---|---|---|---|---|
| | | % | % | % |
| 1 | 1 | 19.3 | 19.7 | 10.8 |
| 2 | 1 | 14.6 | 17.7 | 9.7 |
| 3 | 1 | 11.8 | 15.3 | 8.1 |
| 4 | 1 | 11.8 | 11.7 | 9.7 |
| 5 | 1 | 11.1 | 13.7 | 12.0 |

[a] These data were obtained by Mr. W. M. Cory, Farm Advisor in Orange County, California.
[b] Air dry basis.

were in the same Federal grade but varied greatly in some of the chemical constituents.

From studies on 31 alfalfa hays of great variation in quality, Meyer and Lofgreen (1956) reported regression equations which would allow one to predict with reasonable accuracy the TDN content from a lignin or crude fiber analysis. Even though it was of academic interest to develop regression equations to describe these relationships, they were useful only in controlled nutritional investigation and had little direct practical application in the field. Therefore, experimental work was initiated to develop a procedure by which chemical analyses could be used to reduce much of the uncertainty when hay is graded or evaluated for livestock feed. The experimental work involved: (1) choice and simplification of analytical methods, (2) development of new regression equations, (3) development of an apparatus to sample baled hay, (4) investigation of the variation that might be expected within populations of hay bales, (5) determination

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of the sampling procedure and the number of samples needed for an adequate sample and (6) development of tables so that monetary value of hay could be readily calculated.

## Experimental

The results of Meyer and Lofgreen (1956) demonstrated that both lignin and crude fiber had higher correlation coefficients than nitrogen when related to TDN. These results and the fact that lignin is a substance which directly influences digestibility led to the choice of either lignin or crude fiber for predicting TDN. Of the two, crude fiber is the simpler to

TABLE 2. CRUDE FIBER, SILICA AND CRUDE FIBER ASH IN SAMPLES [a]

| Sample | | Crude fiber | | | Silica | Ash from crude fiber | Crude fiber modified [b] |
|---|---|---|---|---|---|---|---|
| | | By A.O.A.C. | No ether extraction | Alchol-benzene extraction | | | |
| | | % | % | % | % | % | % |
| Alfalfa | 1 | 26.0 | 27.1 | 26.9 | 0.6 | 0.6 | 27.5 |
| Alfalfa | 2 | 22.4 | 23.8 | 23.0 | 1.2 | 1.0 | 24.0 |
| Alfalfa | 3 | 28.8 | 30.5 | 30.0 | 0.3 | 0.6 | 30.6 |
| Alfalfa | 4 | 29.6 | 31.1 | 30.1 | 0.3 | 0.6 | 30.7 |
| Alfalfa | 5 | 23.9 | 24.8 | 23.8 | 1.0 | 0.8 | 24.6 |
| Alfalfa | 6 | 26.5 | 28.2 | 26.6 | 0.2 | 0.4 | 27.0 |
| Mixed ration | 1 | 16.4 | 17.9 | 16.6 | 0.3 | 0.3 | 16.9 |
| | 2 | 16.0 | 17.4 | 16.6 | 1.4 | 0.4 | 17.0 |
| Mean | | 23.7 | 25.1 | 24.2 | 0.7 | 0.6 | 24.8 |

[a] Dry matter basis.
[b] "Crude fiber plus silica".

determine and therefore seemed to be the constituent of choice for application in field work.

An effort was made to revise the crude fiber determination so that it could be made in 4 hours. Elimination of preliminary extraction of the sample with ether resulted in high crude fiber values (table 2). However, swirling or mixing the sample in 200 ml. of a warm ethanol-benzene mixture (32 parts 95% ethanol to 68 parts by weight of benzene) for 5 minutes and filtering on a linen cloth followed by three washings with ethanol permitted crude fiber values nearly equal to those obtained by the A.O.A.C. (1955) procedures (table 2). An overhead blender or a magnetic-type stirrer was satisfactory for mixing. Therefore, this modification was adapted when time consumed by the usual ether extraction was a factor.

If, in the crude fiber determination, the final ashing step could be eliminated and the residue (crude fiber plus ash) used instead of crude fiber, further time and equipment would be saved in the determination. An

investigation was made to determine if the ash remaining after burning the residue was largely silica, because previous refluxing with acid would have tended to remove all the minerals except silica. Silica is only slightly soluble in alkali. Results (table 2) seemed to indicate that much of the remaining ash was silica. Furthermore, inclusion of this silica as part of the crude fiber seemed desirable. Silica usually means soil contamination and does not have nutritive value. Since the fibrous portion of the hay has less nutritive value than the non-fibrous portion, inclusion of the silica with the fiber might be a better indication of hay quality than treating it as part of the non-fibrous portion. The standard error of the estimate of the

TABLE 3. REGRESSION AND CORRELATION OF ALFALFA CONSTITUENTS WITH TDN AND DIGESTIBLE PROTEIN [a]

| Item | Regression equation [b] | Standard error of the estimate | Correlation coefficient |
|---|---|---|---|
| | Total digestible nutrients | | |
| Lignin | $Y=79.1-2.67X$ | 3.13 | −.84** |
| Crude fiber | $Y=78.7-0.8027X$ | 2.84 | −.87** |
| Modified crude fiber | $Y=81.07-0.8558X$ | 2.52 | −.89** |
| Protein | $Y=1.142X+33.33$ | 3.41 | 0.80** |
| | Digestible protein | | |
| Lignin | $Y=30.6-1.21X$ | 1.94 | −.85** |
| Crude fiber | $Y=29.5-0.5168X$ | 1.95 | −.85** |
| Modified crude fiber | $Y=30.7-0.5416X$ | 1.89 | −.86** |
| Protein | $Y=0.9155X-3.1$ | 0.63 | 0.99** |

[a] Digestion trials conducted on 43 different samples of alfalfa hay.
[b] Y equals total digestible nutrients or digestible protein, as the case may be; X equals lignin, crude fiber, modified crude fiber or protein, as the case may be. All results are reported on an oven-dry basis.
** Significant at the 1% level.

regression equations was lower when the silica was considered as part of the crude fiber. Therefore, the following modification of the A.O.A.C. (1955) procedure was adapted: After the 30-minute refluxing with boiling NaOH, filter through a weighed Gooch or fritted disc crucible and wash with boiling water followed by ethanol. Dry and weigh the crucible and residue. The difference between the total weight and the weight of crucible is the "crude fiber plus silica".[2]

Because of the above suggested crude fiber method and the availability of several more digestion trial results, a re-examination was made of the data presented by Meyer and Lofgreen (1956). All the hay samples were reanalyzed for crude fiber by the modified method. These data plus nine new alfalfa hays were used to calculate new regression equations (Snedecor, 1946). Because of the new samples, regression equations slightly different

[2] A small amount of other mineral matter might be included with the silica.

from those presented earlier (Meyer and Lofgreen, 1956) were obtained when relating TDN to the lignin, crude fiber or protein content. Crude fiber by the modified method had the highest correlation and the lowest standard error of the estimate, indicating an advantage to the inclusion of silica.

Further calculations indicated that digestible protein could be predicted from the lignin or crude fiber content (table 3). Here, also, a slight advantage resulted when silica was included in the crude fiber. A very high cor-

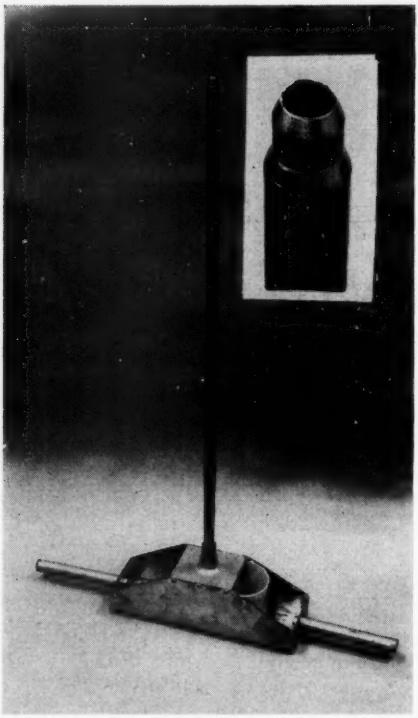

**Figure 1. Manually operated probe. The removable tip is of hardened steel, sharpened, and has a ⅜-inch opening. The inside diameter after a short distance from the tip becomes larger so the hay particles will fall easily into the paper carton. The total length of the tube is 24 inches. This probe was developed by G. H. Bath and L. M. Harwood of the California Agriculture Extension Service, Santa Rosa, California.**

relation coefficient (0.99) existed between crude protein and digestible protein.

On the basis that one analysis could be used to predict TDN and digestible protein, it was decided to choose the modified crude fiber method. While modified crude fiber was not as satisfactory as protein in predicting digestible protein, it was superior in predicting TDN. We believe that improved accuracy in predicting an energy measurement was more important than predicting digestible protein. Furthermore, the modified crude fiber was slightly superior to lignin and crude fiber and is a simpler and more rapid analysis requiring less laboratory equipment.

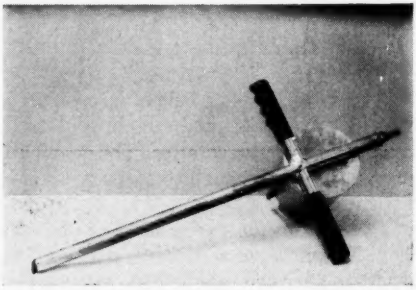

**Figure 2. A ¾-inch auger made of carpenter's bits welded together draws the hay through the tube and drops the hay into the paper carton. It is powered by a ½-inch electric drill.**

Next, a simple yet reliable method of obtaining a representative sample from baled hay was needed. Two samplers (figures 1 and 2) were found to operate satisfactorily. Figure 1 shows a manually-operated probe which is pushed 18 inches into the end of a bale of hay. It operates very easily in dry hay but less easily in hay with more than 15% moisture. The other sampler (figure 2) is powered by a half-inch electric drill. Ordinary wood bits are welded together to provide an 18-inch auger through the tube. Many modifications of the tip of the bit have been tried, and the most satisfactory seems to be where the lips extending forward have a slight set outwards so the hole made by the bit is the same size as the tube. This sampler also is difficult to operate in high-moisture hay. Both, however, have the advantage of delivering the hay directly into a carton. For high-moisture hay, a revolving tube with a segment of a band saw blade mounted on the end with the teeth set slightly inward and powered by an electric drill seems to be the most satisfactory.

Several methods of sampling baled hay were tested and compared. A study of the means and standard deviations in table 4 reveals that all of

TABLE 4. INFLUENCE OF VARIOUS METHODS OF SAMPLING ON THE COMPOSITION OF HAY [a]

| Number and method | No. of samples | 3/8-inch probe [b] | 3/4-inch probe [b] | 3/4-inch auger [c] | 1 1/4-inch revolving tube [d] | Composite of hand samples [e] | Composited bale [f] |
|---|---|---|---|---|---|---|---|
| Lot 1, crude fiber, % | 6 | 31.3±0.6 | 31.2±0.6 | ..... | 31.2±0.1 | 32.2±1.1 | 31.2±0.9 |
| Lot 2, crude fiber, % | 6 | 27.6±0.3 | ..... | ..... | ..... | 28.1±0.2 | ..... |
| Lot 3, crude fiber, % | 14 | ..... | 31.8±1.4 | ..... | ..... | 33.0±1.4 | ..... |
| Lot 4, crude fiber, % | 14 | 29.6±1.2 | ..... | ..... | ..... | 29.5±1.7 | ..... |
| Lot 5, protein, % | 9 | ..... | ..... | 23.5±1.9 | ..... | ..... | 23.0±2.1 |
| Lot 6, crude fiber, % | 10 | 27.2±1.5 | ..... | ..... | ..... | ..... | 28.7±1.4 |

[a] Mean and standard deviation.
[b] See figure 1.
[c] See figure 2.
[d] Band saw teeth welded to a tube which is powered by a 1/2-inch electric drill.
[e] Four large hand samples (500 gm. each) taken from various parts of the bale of hay, ground, mixed and quartered for the laboratory sample.
[f] Entire bale ground and quartered for the laboratory sample.

the various methods seem to sample a bale of hay within reasonable limits. Apparently as long as a complete core sample is taken from the end of the bale, the sample will be representative. The 3/8-inch probe (figure 1) seems to be the sampling device of choice because of its simplicity of construction and operation.

Information was needed on the variation one might find between bales within a population. Therefore, some individual bales from six lots of hay were analyzed for crude fiber or protein. The coefficients of variation were calculated (table 5). The weighted average of these was 5.94%. The formula given by Snedecor (1946), $n = t^2C^2/p^2$, was used. Here, n equals the number of bales needed for sampling from a population; t equals 2.878; C equals the coefficient of variation found, 5.94%; while p equals the fiducial interval as a percent of the mean. In this, a fiducial interval was chosen which would estimate TDN within one percentage unit. Calculations revealed that 19 bales of hay sampled at random from a population would provide a sample which would estimate the TDN within one percentage unit. A population could be any size as long as the hay was from one field, harvested at the same time and at the same maturity stage.

TABLE 5. COEFFICIENT OF VARIATION OF SOME HAY BALE POPULATIONS

| No. bales in sample | Protein coefficient of variation | Crude fiber coefficient of variation |
|---|---|---|
| | % | % |
| 45 | 7.74 | 5.24 |
| 12 | 5.05 | 6.45 |
| 12 | 6.75 | 7.83 |
| 17 | 2.54 | .... |
| 12 | 4.32 | .... |
| 12 | 5.90 | .... |

The final application of an estimate of alfalfa hay value requires a table from which estimated TDN and digestible protein could easily be obtained from the moisture and crude fiber content rather than from the regression equations, and a table for determining the monetary value of hay relative to common feed sources of energy and protein. The first table could easily be calculated from the equations given in table 3 and applied at different dry matter levels. The second table by which hay could be compared to common feed sources of energy and protein required further

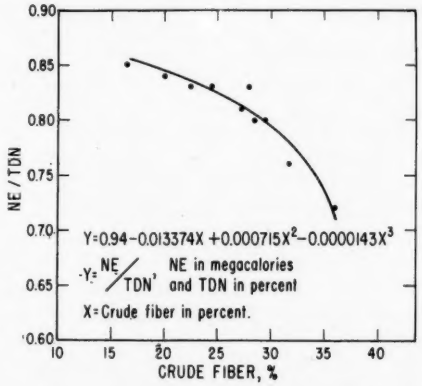


**Figure 3. Relationship between the crude fiber content of alfalfa hay and the net energy (NE)—total digestible nutrient (TDN) ration.**

calculations. It was decided that comparisons to barley and cottonseed meal would be most satisfactory for California conditions. Other feeds could easily be used. Comparison of feeds varying in crude fiber are more properly made on a net energy and digestible protein basis in such a system as that devised by Petersen (1932). Consequently, the net energy of the hay should be considered. Calculations from Morrison (1956) showed that at 16% crude fiber one pound of TDN was equivalent to 0.85 megacalories of net energy, while at 40% crude fiber one pound was equivalent to only 0.63 megacalories. Furthermore, by taking the available data from Morrison (1956) and plotting the NE/TDN ratios against crude fiber level, a very smooth curve was obtained (figure 3). This allowed a calculation of the net energy per unit of TDN in alfalfa hay at various crude fiber levels.

Through the use of the system devised by Petersen (1932), modified to include NE rather than TDN, table 6 was prepared. The 1946 to 1956 ten-year average price of barley and cottonseed meal in California was

used as a base for preparing the table. The table can be used by merely multiplying the evaluation factors (depending on the crude fiber in the alfalfa hay) for barley and cottonseed meal by the present or expected prices of barley and cottonseed meal and totaling the results to obtain the price one should pay for hay. This helps compare the monetary value

TABLE 6. EVALUATION FACTORS FOR ALFALFA HAY AT VARYING CRUDE FIBER LEVELS [a]

| Crude fiber | Evaluation factors | | |
|---|---|---|---|
| | Barley factor | Cottonseed meal factor | Net energy constants |
| % | | | |
| 18 | 0.169 | 0.526 | 0.70 |
| 19 | 0.177 | 0.507 | 0.69 |
| 20 | 0.195 | 0.491 | 0.68 |
| 21 | 0.198 | 0.476 | 0.67 |
| 22 | 0.206 | 0.458 | 0.66 |
| 23 | 0.208 | 0.448 | 0.65 |
| 24 | 0.209 | 0.429 | 0.64 |
| 25 | 0.212 | 0.410 | 0.63 |
| 26 | 0.217 | 0.390 | 0.61 |
| 27 | 0.220 | 0.382 | 0.60 |
| 28 | 0.221 | 0.366 | 0.59 |
| 29 | 0.227 | 0.349 | 0.58 |
| 30 | 0.239 | 0.331 | 0.57 |
| 31 | 0.254 | 0.317 | 0.56 |
| 32 | 0.250 | 0.298 | 0.55 |
| 33 | 0.243 | 0.289 | 0.54 |
| 34 | 0.245 | 0.275 | 0.52 |
| 35 | 0.257 | 0.249 | 0.50 |
| 36 | 0.254 | 0.242 | 0.48 |
| 37 | 0.246 | 0.231 | 0.47 |
| 38 | 0.242 | 0.216 | 0.45 |
| 39 | 0.238 | 0.202 | 0.43 |
| 40 | 0.230 | 0.188 | 0.42 |
| 41 | 0.234 | 0.170 | 0.40 |
| 42 | 0.218 | 0.160 | 0.38 |
| 43 | 0.223 | 0.146 | 0.37 |
| 44 | 0.227 | 0.126 | 0.35 |

[a] Dry matter basis.

of hay to that of the main feed sources of energy and protein—in this case barley and cottonseed meal. Where protein is not a consideration, the net energy constants, only, would be used.

*Discussion*

The foregoing system is suggested as a means of taking much of the variation out of visually estimating alfalfa hay value. It only supplements

existing hay grading standards because a visual examination is still needed.

The California Agricultural Extension Service has used this system in the field for the past year. Sampling procedures have not proven laborious or impractical. The laboratory work has been done by commercial laboratories, dairy cooperatives, feed companies, hay grower cooperatives and Extension laboratories. Laboratory work has not proven to be a bottleneck when the laboratories have been alerted and designed to make rapid analyses when needed. California livestockmen have received the system well and many dairymen have insisted that all the hay they purchase be analyzed for crude fiber. From 10-ton to 400-ton lots in a population of hay have been sampled in a satisfactory manner.

A system utilizing chemical analysis to evaluate hay will be more important with pelleted hay than with long, chopped or baled hay. Many of the samples used in these data were from digestion trials with pelleted alfalfa. Meyer *et al.* (1959) and Weir *et al.* (1959) have reported no differences in TDN between pelleted and non-pelleted alfalfa hay. It is expected, therefore, that the results reported here will apply to pelleted hay.

## Summary

A method has been proposed for a critical evaluation of alfalfa hay quality by the use of chemical analysis. A modification of the crude fiber method was made so that the remaining ash, which was shown to be largely silica, was included in the crude fiber. A study of regression equations relating total digestible nutrients (TDN) and digestible protein to lignin, crude fiber, "crude fiber plus silica", and protein revealed that the modified crude fiber was most satisfactory for predicting both TDN and digestible protein. Therefore, determination of dry matter and "crude fiber plus silica" will allow the prediction of TDN and digestible protein content.

Studies of hay sampling devices and variation in composition of hay suggest that core samples ⅜-inch by 18-inch from 19 bales of hay in a population will provide a representative sample of that lot of hay for chemical analysis so that 95% of the time the predicted TDN will be within one percentage unit. A table of constants is presented which allows the monetary value of alfalfa hay to be calculated relative to the price of barley and cottonseed meal depending on the crude fiber content of the alfalfa hay.

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# EFFECT OF STILBESTROL AND AMOUNT OF CORN SILAGE IN THE RATION UPON THE PROTEIN REQUIREMENT OF FATTENING STEER CALVES [1]

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RESEARCH has been conducted at the Ohio Agricultural Experiment Station since 1953 to study the possible effects of various factors upon the protein requirement of fattening steers. The apparent effect of hay quality and molasses (Klosterman *et al.*, 1956) and non-effect of stilbestrol (Klosterman, Cahill, Kunkle and Moxon, 1958) upon protein requirements have been reported.

The relationship between available calories and protein content of poultry rations has been well established (Norris, 1958). Interactions between energy and protein content of sheep rations have been reported by Preston and Burroughs (1958) and Jones, Hogue and Hunt (1958). This relationship has also been studied in swine (Abernathy *et al.*, 1958) and cattle (Matsushima *et al.*, 1957; Winchester *et al.*, 1957a, 1957b; Bohman *et al.*, 1958; Dyer and Ham, 1958).

The present experiments were undertaken to study further the effect of stilbestrol upon protein requirement and to study the possible relationships between protein and energy levels in rations for fattening steer calves.

## Procedure

*1956–1957 Experiment.* Eight lots of seven Hereford steer calves each were fed. The average initial weight of these steers was 480 lb. Average initial weights of steers in the various lots ranged from 476 to 485 lb. Four lots were full-fed ground ear corn and four were fed approximately one-half as much ground ear corn and a full feed of well-eared corn silage. Two levels of total crude protein, approximately 8.5 and 10%, were fed with each of these rations. One lot fed each level of protein was implanted with 36 mg. of stilbestrol per head at the start of the experiment. These experimental rations were fed for a total of 266 days.

*1957–1958 Experiment.* A total of nine lots each of seven Hereford steer calves weighing 550 lb. initially were fed in this experiment. Average initial weights of the calves by lots ranged from 544 to 558 lb. Three lots were fed 5 lb. of concentrates (ground ear corn and soybean oil meal) per head daily with a full feed of well-eared corn silage. Three lots were fed 10 lb. of concentrates per head daily with a full feed of corn silage and three lots were full-fed ground ear corn and no silage. Three levels of total

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crude protein, approximately 9.25, 10.5, and 11.75% in the total air dry ration, were fed with each of these three levels of concentrates. All steers in this experiment were implanted with 36 mg. of stilbestrol per head at the start and were fed for a total of 223 days.

The following procedures were common to both experiments. The levels of protein fed were obtained by adding various amounts of solvent-extracted soybean oil meal to the ration. All lots were fed good quality, light legume mixed timothy hay and allowed free access to salt and to a mineral mixture of two parts steamed bonemeal, two parts ground limestone and one part salt. The corn silage fed was estimated to have yielded, if harvested for grain, approximately 90 bushels of ear corn per acre. At the conclusion of the experiments all cattle were slaughtered and individual grades and dressing percentages were obtained. All feeds were analyzed periodically for total crude protein and moisture. In the calculations of the protein content of the total ration, corn silage was converted to an 85% dry matter basis. Determinations of estimated net energy (ENE) were based on values given by Morrison (1956). The value of 15.2 Therms per 100 lb. for well-eared corn silage for cattle not followed by pigs was used.

## Results and Discussion

Analysis of variance (Snedecor, 1956) of the average daily gains made by the steers fed in the 1956–1957 experiment (table 1) showed significant differences, $P = .05$, due to stilbestrol and levels of protein and a highly significant difference, $P = .01$, between steers full-fed ground ear corn and those fed ear corn and corn silage. The increase in daily gain of 0.13 lb. due to stilbestrol implantation, although significant, was considerably smaller than obtained in a large number of other experiments. This smaller increase can most likely be explained by the fact that all rations fed in this experiment were sub-optimal in protein content. Previous studies (Klosterman *et al.*, 1958) have shown that a maximum response from stilbestrol is dependent upon a ration adequate in protein. In the current experiment, interactions between energy, protein, and stilbestrol did not approach significance; thus stilbestrol tended to have the same effect with all rations. However, on the full-fed corn ration the increase in gain from stilbestrol with the higher protein ration was double that obtained with the low protein ration. This is in agreement with the previous experiments.

It is of considerable practical interest that the steers fed a half-feed of ground ear corn with corn silage full-fed gained 0.20 lb. per head per day faster than those full-fed ground ear corn and no silage. With the ENE values used, steers fed corn silage required less energy (highly significant) per hundredweight gain than those full-fed ground ear corn.

Stilbestrol implantation lowered the carcass grade significantly by 0.27 of a grade. This effect was greater, 0.38 grade reduction, with the full-fed corn ration than with the silage ration, 0.18 grade. Cattle fed the lower

TABLE 1. EFFECT OF STILBESTROL AND AMOUNT OF GROUND EAR CORN IN THE RATION UPON THE PROTEIN REQUIREMENT OF FATTENING STEER CALVES

1956–1957 EXPERIMENT

| Calories (ENE) per lb. of air dry ration | Corn and corn silage 568 | | Corn 678 | | Average 623 |
|---|---|---|---|---|---|
| Level of protein | Low | Medium | Low | Medium | |
| | Control | | | | |
| Digestible protein per head daily, lb. | 0.91 | 1.20 | 1.00 | 1.27 | 1.10 |
| Av. daily gain, lb. | 1.93 | 2.11 | 1.75 | 1.85 | 1.91 |
| Av. daily ration, lb. | | | | | |
| Ground ear corn | 6.8 | 6.5 | 13.3 | 12.6 | 9.8 |
| Soybean oil meal | 0.26 | 1.0 | 0.26 | 1.0 | 0.63 |
| Hay | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| Corn silage | 23.9 | 23.4 | | | 11.8 |
| Therms ENE per cwt. gain | 492. | 462. | 603. | 578. | 534. |
| Dressing percentage | 59.2 | 60.6 | 60.0 | 61.0 | 60.2 |
| Carcass grades[a] | 10.3 | 10.9 | 10.3 | 11.4 | 10.7 |
| | Stilbestrol implantation, 36 mg. | | | | |
| Digestible protein per head, daily, lb. | 0.94 | 1.24 | 1.04 | 1.33 | 1.14 |
| Av. daily gain, lb. | 2.09 | 2.16 | 1.85 | 2.05 | 2.04 |
| Av. daily ration, lb. | | | | | |
| Ground ear corn | 7.1 | 6.9 | 13.9 | 13.6 | 10.4 |
| Soybean oil meal | 0.26 | 1.0 | 0.26 | 1.0 | 0.63 |
| Hay | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| Corn silage | 25.0 | 24.5 | | | 12.4 |
| Therms ENE per cwt. gain | 472. | 476. | 597. | 555. | 525. |
| Dressing percentage | 58.8 | 60.0 | 59.4 | 60.4 | 59.7 |
| Carcass grade[a] | 10.0 | 10.1 | 9.3 | 10.1 | 9.9 |
| | Average | | | | |
| Digestible protein per head daily, lb. | 0.92 | 1.22 | 1.02 | 1.30 | |
| Av. daily gain, lb. | 2.01 | 2.14 | 1.80 | 1.95 | |
| Av. daily ration, lb. | | | | | |
| Ground ear corn | 7.0 | 6.7 | 13.6 | 13.1 | |
| Soybean oil meal | 0.26 | 1.0 | 0.26 | 1.0 | |
| Hay | 2.1 | 2.1 | 2.1 | 2.1 | |
| Corn silage | 24.4 | 24.0 | | | |
| Therms ENE per cwt. gain | 482. | 469. | 600. | 566. | |
| Dressing percentage | 59.0 | 60.3 | 59.7 | 60.7 | |
| Carcass grade[a] | 10.2 | 10.5 | 9.8 | 10.8 | |

[a] Grade factors: low, average, and high choice 10, 11, 12; low, average, and high good 7, 8, 9.

protein ration graded significantly lower than those fed the higher protein ration. Although possibly due to chance, there appears to be less difference in carcass grade between the two levels of protein when fed with corn silage than when fed without. The lowest carcass grade obtained was with the low protein ration and a full feed of ground ear corn.

These effects of protein level and stilbestrol upon carcass grade are in

agreement with previous studies at this Station (Klosterman *et al.*, 1958) but not with observations made by Burroughs *et al.* (1958). Burroughs reported that when stilbestrol was included in the ration carcass grade was increased by reducing the amount of protein in the ration from 12.5 to 9.9%. However, heavier and apparently older cattle were used in their experiments and the increase in carcass grade was only one-tenth of a grade. In experiments with fattening steer calves at this Station, a reduction in amount of protein in the ration has had either no effect on carcass grade, or, if the reduction was sufficient to lower rate of gain significantly, carcass grade was also decreased. This has been true without stilbestrol and with stilbestrol administered either orally or subcutaneously.

Statistical analyses of average daily gains and carcass grades obtained in the 1957–1958 experiment (table 2) indicated no significant differences due to experimental treatments. There was, however, a highly significant difference in amount of estimated net energy required per unit of gain. The amount of energy required per unit of gain increased with each increase in amount of ground ear corn fed.

The two experiments reported here indicate a very high value for well-eared corn silage for growing-fattening steers. Cattle fed silage with ground ear corn have gained as fast or faster than those full-fed ground ear corn. This occurred even though the amount of ground ear corn fed was reduced to one-half or even one-third full feed. These results suggest a higher ENE value for silage than that shown by Morrison (1956). Morrison shows a value of 15.2 Therms per 100 lb. for cattle not followed by pigs. The steers fed in these experiments were not followed by pigs and hence no pork credit was obtained. When the amounts of feed required per hundredweight gain and the ENE values of Morrison for feeds other than silage were used, a value of 23.9 Therms per 100 lb. silage was calculated from these experiments. If this value were converted to an 85% dry matter basis, it would become 72.4 Therms or fully equal to ground ear corn. In consideration of this figure and the performance of the steers, there may be a question whether different levels of energy were fed in these experiments.

The ENE values used here have been those of Morrison (1956). These values were calculated largely from comparative feeding experiments, total digestible nutrient content, and chemical composition of the various feeds. An estimated value from any two experiments, such as those reported here, may be expected to vary from the average of a large number of comparisons as determined by Morrison. However, it is also possible that much of the present day silage made from well-fertilized, hybrid corn may be higher in grain content than the average used by Morrison.

Corn silage has long been known to have a higher feeding value for fattening cattle than can be explained by its digestible nutrient content. This observation was repeated in these experiments where no pork credit was added to the gains made by the cattle. On a dry basis, corn silage is relatively high in organic acids, principally acetic and lactic. Bentley,

TABLE 2. EFFECT OF AMOUNT OF GROUND EAR CORN IN THE RATION UPON THE PROTEIN REQUIREMENT OF FATTENING STEER CALVES

1957–1958 EXPERIMENT

| Item | Level of protein | | | Average |
|---|---|---|---|---|
| | Low | Medium | High | |
| ENE, 516 calories per lb. of air dry ration | | | | |
| Digestible protein per head daily, lb. | 1.19 | 1.46 | 1.66 | 1.44 |
| Av. daily gain, lb. | 2.11 | 2.39 | 2.30 | 2.27 |
| Av. daily ration, lb. | | | | |
| Ground ear corn | 4.2 | 3.5 | 2.9 | 3.5 |
| Soybean oil meal | 0.8 | 1.5 | 2.1 | 1.5 |
| Hay | 2.0 | 2.0 | 2.0 | 2.0 |
| Corn silage | 36.9 | 38.5 | 36.9 | 37.4 |
| Therms ENE per cwt. gain | 475. | 431. | 441. | 449.0 |
| Dressing percentage | 60.9 | 60.6 | 60.3 | 60.6 |
| Carcass grade[a] | 10.3 | 11.0 | 10.3 | 10.5 |
| ENE, 576 calories per lb. of air dry ration | | | | |
| Digestible protein per head daily, lb. | 1.36 | 1.62 | 1.83 | 1.60 |
| Av. daily gain, lb. | 2.40 | 2.31 | 2.47 | 2.39 |
| Av. daily ration, lb. | | | | |
| Ground ear corn | 9.1 | 8.4 | 7.8 | 8.4 |
| Soybean oil meal | 0.9 | 1.6 | 2.2 | 1.6 |
| Hay | 2.0 | 2.0 | 2.0 | 2.0 |
| Corn silage | 27.3 | 27.4 | 27.0 | 27.2 |
| Therms ENE per cwt. gain | 507. | 530. | 494. | 510. |
| Dressing percentage | 62.4 | 61.4 | 61.4 | 61.7 |
| Carcass grade[a] | 10.6 | 10.4 | 9.6 | 10.2 |
| ENE, 692 calories per lb. of air dry ration | | | | |
| Digestible protein per head daily, lb. | 1.43 | 1.72 | 1.87 | 1.67 |
| Av. daily gain, lb. | 2.25 | 2.42 | 2.24 | 2.30 |
| Av. daily ration, lb. | | | | |
| Ground ear corn | 17.1 | 17.2 | 15.1 | 16.5 |
| Soybean oil meal | 0.9 | 1.6 | 2.2 | 1.6 |
| Hay | 2.0 | 2.0 | 2.0 | 2.0 |
| Therms ENE per cwt. gain | 614. | 594. | 599. | 602. |
| Dressing percentage | 60.7 | 63.1 | 61.9 | 61.9 |
| Carcass grade[a] | 10.6 | 10.7 | 10.6 | 10.6 |
| Average | | | | |
| Digestible protein per head daily, lb. | 1.33 | 1.60 | 1.79 | |
| Av. daily gain, lb. | 2.25 | 2.37 | 2.34 | |
| Av. daily ration, lb. | | | | |
| Ground ear corn | 10.1 | 9.7 | 8.6 | |
| Soybean oil meal | 0.9 | 1.6 | 2.2 | |
| Hay | 2.0 | 2.0 | 2.0 | |
| Corn silage | 21.4 | 22.0 | 21.3 | |
| Therms ENE per cwt. gain | 532. | 518. | 511. | |
| Dressing percentage | 61.3 | 61.7 | 61.2 | |
| Carcass grade[a] | 10.5 | 10.7 | 10.2 | |

[a] Grade factors: low, average, and high choice 10, 11, 12; low, average, and high good 7, 8, 9.

*et al.* (1956) have reported a high feeding value for salts of these acids when fed to growing-fattening lambs. Preliminary results with fattening cattle (Klosterman *et al.*, 1958) also suggest a relatively high feeding value for lactic acid. Fundamental studies are needed on the relative energy value of the various nutrient constituents of corn silage.

## Summary

The effects of stilbestrol implantation and level of corn silage in the ration upon the protein requirement of fattening steer calves were studied. Protein requirement, as measured by rate of gain and carcass grade, was not significantly influenced by stilbestrol. When fed with approximately one-third, one-half or two-thirds of a full feed of ground ear corn, well-eared corn silage was found to have a high estimated net energy value. The level of corn silage included in the ration had no apparent effect upon the amount of protein required.

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# EFFECT OF VITAMIN D AND OF SHEARING ON EWE LAMBS

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DURING the usual winter in the Coast Range of California the skies are overcast with fog and clouds a large proportion of the time; the sun is low on the horizon, and the ultra violet light rays are relatively weak. Since sheep are commonly shorn in the spring months they pass the winter in fairly long fleeces and are almost completely covered with wool. It would appear that under range conditions sheep in this area not having access to suncured hay might have marginal or submarginal vitamin D intake.

Experimental work by Fitch (1943), Ewer and Bartrum (1948) and Grant (1954–55) has shown that under New Zealand winter conditions hoggets (weaned lambs) are subject to rickets while being carried on green pasture. These workers have demonstrated that high carotene content of green growing forage interfered with utilization of marginal intake of vitamin D, thus producing rickets in the lambs. The early administration of large quantities of vitamin D by mouth has been effective in preventing rickets in New Zealand lambs.

While rickets has been uncommon in Coast Range lambs, it was considered possible that a subclinical avitaminosis D might exist in the area. Therefore, this experiment was undertaken to measure the effects of vitamin D supplementation and shearing date on ewe lambs.

## Procedure

Two hundred ewe lambs at the Hopland Field Station were included in the trial. These lambs were of mixed whitefaced type but with Corriedale breeding predominanting; they were born during January and February of 1957. Because of mortality during the early part of the experiment, complete data were gathered on 193 lambs. These lambs were in a feeding experiment from July 16 to December 2, 1957 in which different feeds were being compared for their value as supplements to range forage. In that experiment the lambs were divided into six groups which received the following supplements: (1) none (control); (2) pelleted alfalfa cut in the full bloom stage; (3) pelleted alfalfa cut in the bud stage; (4) a mixture of equal parts cottonseed meal and barley; (5) cottonseed meal alone and (6) barley alone. Groups 2 to 6 received ½ lb. per head per day of the supplement fed six days per week.

Starting August 16, 1957 the experiment on vitamin D and effects of shearing was combined factorially with the feeding experiment noted above. For this purpose the animals were allotted within feeding test groups

into six sub-groups on the basis of sire, dam shearing weights for 1956, type of birth, and body weight. The result was six groups of animals treated as follows: Groups I (34 lambs) and II (31 lambs) were shorn on August 16, 1957 and again on April 28, 1958. Groups III (33 lambs) and IV (31 lambs) were shorn on March 10, 1958 and again on April 28, 1958. Groups V (32 lambs) and VI (32 lambs) were shorn on April 28, 1958. All lambs had been shorn previous to the start of the feeding experiment on May 5, 1957.

Groups I, III and V received 1 million units of vitamin D by intramuscular injection on December 2, 1957. Groups II, IV and VI received no supplementary vitamin D. The animals were weighed July 16, 1957 and again at the end of the experiment (April 29, 1958) after a 12-hour overnight stand without food or water.

Weights on a non-shrunk basis were taken at intervals throughout the trial. Blood samples were also taken for the determination of serum calcium and phosphorus on 10 lambs in each group. Fleeces were weighed from each animal at the various shearings and a side sample of approximately 100 gm. was bagged for shrinkage determination. The latter step allowed the calculation of clean weight of fiber for each animal at each shearing period throughout the trial.

The weight gain and wool data were subjected to analysis of variance in which the effects of rations, shearing dates, vitamin D supplementation and the various interactions were considered.

## Results and Discussion

The mean individual weight gains and clean wool production for the different shearing and vitamin D treatments are given in table 1.

TABLE 1. MEAN INDIVIDUAL WEIGHT GAINS AND CLEAN FIBER PRODUCTION OF EWE LAMBS

| Experimental group | Treatment | No. of lambs | Weight gain, lb. July 16/57–April 29/58 | Total clean wool production, lb. May 5/57–April 28/58 |
|---|---|---|---|---|
| I and II | Shorn Aug. 16, 1957 and Apr. 28, 1958 | 65 | 25.2 | 7.07 |
| III and IV | Shorn Mar. 10, 1958 and Apr. 28, 1958 | 64 | 21.5 | 6.12 |
| V and VI | Shorn Apr. 28, 1958 | 64 | 23.1 | 6.10 |
| I, III and V | 1,000,000 I.U. vit. D on Dec. 2, 1957 | 99 | 22.9 | 6.30 |
| II, IV and VI | No vitamin D | 94 | 23.6 | 6.57 |

In the analysis of the data on gains none of the treatment effects or interactions were significant, although the effect of shearing date approached significance (the August-shorn lambs gained more).

The supplementary rations fed during the early part of the trial (July 16 to December 2, 1957) did not significantly affect gains over the period July 16, 1957 to April 29, 1958. The maximum difference was between the cottonseed meal group and the controls and amounted to 5.7 lb. The gains of the various groups are in approximately the same order as those of the clean fleece weight which do differ significantly. In contrast to the effect on clean fiber weights any earlier effect of supplementation on body weight was largely overcome in the different groups of lambs at the final weighing date on April 29, 1958.

The lack of response to vitamin D injection under these conditions suggests that the ewe lambs were receiving a sufficient amount of the vitamin in range feed or from exposure to fulfill any need, and that the daily level of carotene intake was insufficient to interfere seriously with vitamin D utilization.

The injection of vitamin D lowered clean fleece production significantly ($P<.05$). The difference between treated and untreated lambs was 0.27 lb. of clean fiber. The reason for this is unknown, but it may indicate that the harmful level of vitamin D was closely approached at the dosage given.

Shearing in August and again in April increased clean wool production as measured by wool shorn compared to shearing in April alone ($P<.01$). The shearing data means were: August, 7.07 lb.; March, 6.12 lb.; and April, 6.10 lb. March shearing and reshearing in April had no effect as compared to April shearing alone. The increased wool production of the fall-shorn group indicates that the animals in shorter fleece were better able to grow or retain their wool until shearing time. Why this is so is not clear, though sheep producers recognize that animals in short fleece carry less water in their fleeces in stormy weather, that their fleeces dry out more quickly, are less susceptible to wool rot and staining, and finally that they lose less wool on brush than animals with long fleeces.

Table 2 shows the mean plasma calcium and phosphorus of the sample ewe lambs bled from each experimental group. The differences in means between groups are small and are not indicative of any significant effect of treatments. Differences in means for all groups between dates could represent differences associated with such factors as activity or length of time of fasting before bleeding. The data show the range of these measurements for lambs kept under these range conditions.

The different supplementary rations given to the lambs early in the experiment affected clean wool production significantly ($P<.01$). Barley did not increase wool production significantly (0.10 lb.) but cottonseed meal and barley (0.64 lb.), full bloom alfalfa (0.69 lb.), bud stage alfalfa (0.82 lb.) and cottonseed meal (0.98 lb.) all resulted in significant increases. This demonstrates again the well-known effect of nutrition on

TABLE 2. CALCIUM AND INORGANIC PHOSPHORUS CONTENT OF PLASMA OF EWE LAMBS [a]

| Experimental group | | I | II | III | IV | V | VI | Mean per date |
|---|---|---|---|---|---|---|---|---|
| | | mg. % | mg. % | mg. % | mg. % | mg. % | mg. % | mg. % |
| July 16, 1957 | Number bled | 12 | 11 | 12 | 9 | 11 | 12 | 11.8 |
| | Ca | 11.16 | 11.03 | 10.89 | 11.07 | 11.20 | 10.72 | 11.00 |
| | P | 6.39 | 6.14 | 5.76 | 5.60 | 5.45 | 5.54 | 5.83 |
| Aug. 16, 1957 | Number bled | 11 | 10 | 12 | 9 | 10 | 11 | 10.5 |
| | Ca | 11.46 | 12.01 | 11.17 | 11.20 | 11.83 | 11.88 | 11.59 |
| | P | 6.80 | 7.04 | 6.32 | 6.39 | 6.04 | 6.46 | 5.51 |
| Dec. 2, 1957 | Number bled | 12 | 11 | 12 | 10 | 11 | 12 | 11.3 |
| | Ca | 10.68 | 11.33 | 11.01 | 11.35 | 11.20 | 10.97 | 11.08 |
| | P | 7.27 | 6.93 | 6.97 | 6.42 | 6.71 | 6.56 | 6.82 |
| Mar. 10, 1958 | Number bled | 9 | 10 | 11 | 9 | 10 | 11 | 10.00 |
| | Ca | 8.79 | 8.77 | 8.80 | 8.54 | 9.28 | 9.41 | 8.95 |
| | P | 9.02 | 8.94 | 7.98 | 7.60 | 7.45 | 8.03 | 8.16 |
| Apr. 28, 1958 | Number bled | 11 | 11 | 11 | 10 | 10 | 12 | 10.8 |
| | Ca | 9.39 | 9.56 | 9.73 | 9.95 | 10.08 | 9.56 | 9.70 |
| | P | 6.31 | 6.16 | 5.98 | 5.61 | 5.61 | 5.84 | 5.93 |
| Mean per group for total period | Number bled | 11 | 10.6 | 11.6 | 9.4 | 10.4 | 11.6 | 10.8 |
| | Ca | 10.37 | 10.55 | 10.35 | 10.43 | 10.74 | 10.50 | 10.49 |
| | P | 7.08 | 7.01 | 6.59 | 6.31 | 6.25 | 6.46 | 6.62 |

[a] Clark and Collip's (1925) method for calcium and Fiske and Subbarow's (1925) method for phosphorus were followed in making determinations on plasma obtained from heparinized whole blood.

wool production. None of the interactions in the analysis of the clean wool data approached significance.

The winter at the Hopland Field Station was one of the wettest on record. The rainfall from December 2, 1957 to April 28, 1958, recorded at a somewhat lower elevation than that where the experiment was conducted, was approximately 45 inches. It appears that neither early shearing nor vitamin D injection gives sufficient practical benefit for ewe lambs under these conditions to make their use advisable.

## Summary

Weanling ewe lambs on range forage were supplemented with different rations from July 16 to December 2, 1957. Lambs were allotted within different ration groups so as to include three groups of lambs each representing a different shearing treatment. On December 2, 1957 half of each shearing treatment group was given 1 million I.U. of vitamin D by intramuscular injection. Weight gains were compared over the period July 16, 1957 to April 29, 1958 and clean wool production over the period May 5, 1957 to April 28, 1958.

Lambs shorn in August and again in April showed a non-significant increase in weight gains (2.1 lb.) but a significant ($P<.01$) increase in clean wool production (0.97 lb.) compared to the group shorn in April alone. Shearing in March and reshearing in April was of no advantage compared to April-shearing alone.

Vitamin D injection tended to decrease gain (not significant) and significantly ($P<.05$) lowered clean wool production, by comparison with controls. Earlier supplementary rations showed no significant effect on weight gains over the total period but did significantly ($P<.01$) affect clean wool production.

Neither vitamin D injection nor early shearing was of sufficient benefit to weanling ewe lambs to warrant use in one of the heaviest rainfall years on record in the Hopland area.

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# SOME EFFECTS OF STILBESTROL AND RELATED HORMONES ON FEEDLOT PERFORMANCE AND CARCASS MERIT OF FED LAMBS

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SOULE'S (1955) review of the use of hormone implants in lamb fattening points to the numerous side effects such as prolapse of the uterus and rectum, blockage of the urinary track, lowered carcass grade and increases in moisture, bone and connective tissue content of the carcass, as well as improved gain and feed efficiency. The seriousness of the side effects was related to the quantity of stilbestrol administered.

Considerable research has indicated increased gains and feed efficiency among lambs as the result of feeding stilbestrol at levels ranging from 2 mcg. per pound of ration up to 4 mg. per day. In some cases where the higher levels were fed, numerous side effects were evident. The prepuce and bulbo urethral gland were larger; there was constant dripping of urine among several lambs; there was some mammary development and edema of the anal area in the wethers; and the carcasses graded lower. (Hale *et al.*, 1953, 1954, 1955; Bell and Erhart, 1955; Jordan *et al.*, 1955.)

In the fall of 1954, the Food and Drug Administration approved the use of a pellet including 10 mg. estradiol and 250 mg. progesterone for use in fattening lambs. This implant caused a 15% or more improvement in rate of gain and feed efficiency of lambs, but in several tests the implanted lambs had a lower dressing percent, and the carcasses shrank more and graded slightly lower. (Henneman *et al.*, 1957; Taylor *et al.*, 1957).

The work reported herein was initiated to study the effect on carcass merit and feedlot performance of implanting this hormone combination and the effect of feeding low levels of stilbestrol.

## Experimental Procedure

### *Experiment 1*

One-hundred-twenty Texas feeder lambs averaging 66 lb. were grouped according to weight, sex and condition, then randomly allotted to three pens and were gradually started on feed November 5, 1954. The lambs had been

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maintained on hay and dry pasture since early October and during that time were ear tagged, paint branded and drenched with phenothiazine. All lambs were self-fed a mixed ration composed of 45 parts kafir, 5 parts molasses, and 50 parts good quality alfalfa hay. The ration fed lambs in Lot 2 contained ½ mg. stilbestrol per pound. Each lamb in Lot 3 was implanted subcutaneously under the jaw with 250 mg. progesterone and 10 mg. estradiol.

Five lambs were randomly selected and removed for slaughter from each of the lots after they had been on feed 61 days. The remainder of the lambs were slaughtered after 92 days on trial.

*Experiment 2*

Seven uniform pairs of native spring lambs, primarily of Hampshire breeding, were used in this experiment. Four pairs were wethers from a relatively uniform flock and all were presumed to be sired by the same ram. They were paired according to weight. Another pair was comprised of twin wethers from the same flock. The other two pairs were twin ewes from a different flock.

The lambs were given a full feed of alfalfa hay and increasing amounts of shelled corn. During this time they were drenched with phenothiazine, shorn and paint branded. They were then weighed and randomly allotted the first week of June, 1955, to individual feeding pens 6 x 3½ feet in size. The lambs remained in these pens for the duration of the experiment except for a 2- to 3-hour period each afternoon when they were let out into a common exercise lot which contained no vegetation.

*Rations.* After allotment the lambs received a mixed ration containing 25 parts cottonseed hulls, 25 parts alfalfa hay, 40 parts kafir and 10 parts molasses. One-half mg. stilbestrol [5] was added per pound of ration for a random member of each pair. The ration was increased so the lambs were on full feed in 10 days, and for the remainder of the trial an excess was available at all times. The lambs were weighed weekly, feed consumption records were kept and daily water consumption was recorded. A mixture of trace mineral salt and bonemeal was available at all times in each pen.

*Slaughter Data.* Two pairs of lambs were slaughtered after 64 days on feed; the remainder after 73 days on feed. The lambs graded low choice at the time of slaughter.

The carcasses were chilled 2 days, then graded, weighed and cut. The trimmed left leg of each carcass was wrapped for cooking tests which were conducted within 3 days. The right leg was wrapped and frozen for cooking tests conducted 2 weeks later.

Both 9-rib racks were separated by knife into edible and inedible

[5] Sample of this ration was assayed for stilbestrol by Ely Lilly and Company. This assay indicated the ration contained 0.505 mg. stilbestrol activity per pound.

portions. Hankins (1947) had shown correlations of 0.98 between the separable fat content of the 9-rib rack and the separable fat content of the lamb carcass. The edible portion was ground three times and a half-pound sample was frozen in a glass jar for later chemical analysis.

*Cooking Tests.* The legs were roasted in preheated ovens at 325° F. in uncovered aluminum roasters. They were cooked until the internal temperature of the roast at the thickest portion reached 180° F. Weights were taken 10 minutes after the legs were removed from the ovens to determine cooking losses.

*Tenderness and Organoleptic Measurements.* The semimembranosus and semitendinosus muscles were removed and cut in ½-inch slices. Panel members were served coded slices on trays and scored each sample for juiciness, tenderness and flavor. Aroma was appraised from the remaining uncut leg in the roasting pan. Seven persons served on the panel for the left legs; five served for the right legs.

The rectus femoris muscle was removed, wrapped, and refrigerated 3 hours before cutting in ¾-inch slices. Four or five slices, depending on the size of the muscle, were cut and ½-inch cores were removed from two positions on each slice. Shear values of the cores were determined with the Warner-Bratzler shear machine.

## Results and Discussion

### *Experiment 1*

Stilbestrol feeding resulted in approximately a 15% improvement in gain and feed efficiency (table 1). The market value of the lambs was less than that of the controls, however, because of (1) slightly lower yield and grade and (2) the fact that 9 of the 34 lambs killed at the end of the feeding period were classed on the rail as yearlings by the U.S.D.A. grader. Packers estimate the value of a yearling carcass as approximately half that of a lamb carcass.

Implanted lambs which finished the 92-day trial gained 44% faster than the control lambs and on 29% less feed per pound of gain. Their market value was much lower than lambs in either Lot 1 or 2. Twenty of the 34 implanted lambs were classed on the rail as yearlings because of shape, color and texture of meat, and mature appearance of bone. The weights of the "yearling" carcasses were similar to those of others in the same lot. Perhaps blockier, shorter-legged lambs than those used in this test would not be so greatly affected by the hormone treatments and might have been classed as lambs. It is recognized, however, that most lambs fattened in the wheat pasture or corn belt areas are of the fine wool or western type.

This same hormone combination has been used at other experiment stations and reported observations have been similar in terms of improved

TABLE 1. EFFECT OF STILBESTROL OR ESTRADIOL–PROGESTERONE COMBINATION ON FEEDLOT PERFORMANCE AND CARCASS MERIT OF LAMBS, EXPERIMENT 1

| Lot | 1 Control | 2 0.5 mg. stilbestrol per lb. feed | 3 10 mg. estradiol and 250 mg. progesterone per lamb |
|---|---|---|---|
| Lambs fed 61 days | | | |
| No. of lambs | 5 | 5 | 5 |
| Cooler shrink, 5 days, % | 4.31 | 4.43 | 5.66 |
| Carcass grade[a] | 3.8 | 4.0 | 2.4 |
| Sheared pelt, % of live wt. | 5.46 | .... | 6.44 |
| Wool, % of live wt. | 3.57 | .... | 2.92 |
| Thickness of skin, mm.[b] | 1.8 | 2.3 | 2.7 |
| Lambs fed 92 days | | | |
| No. of lambs[c] | 35 | 34 | 34 |
| Initial wt., lb. | 66 | 66 | 66 |
| Final wt., lb. | 97 | 102 | 111 |
| Av. daily gain, lb. | 0.34 | 0.39 | 0.49 |
| Feed per 100 lb. gain, lb. | 983 | 825 | 696 |
| Yield, %[d] | 50.9 | 49.8 | 49.4 |
| Carcass grade[a] | 4.86 | 4.71 | 4.50 |
| % classed as yearlings | 0 | 26 | 59 |
| Ease of removing pelts[e] | 1.6 | 2.0 | 3.6 |
| Pelt, % of live wt. | 14.16 | 14.36 | 14.97 |

[a] A score of 3=low good, 4=av. good, 5=high good, 6=low choice.
[b] Average of 10 readings per lamb from a section of skin approximately 2 cm. square. Skin was dried, then fixed in formal saline and imbedded in paraffin. Readings were taken 24 hours after fixing.
[c] A lamb in Lot 2 died of coccidiosis; a lamb in Lot 3 died of pneumonia.
[d] $\text{Yield} = \frac{\text{cold carcass wt.}}{\text{av. final wt.}} \times 100.$
[e] A score of 1=easy, 2=normal, 3=difficult, 4=very difficult.

gains and feed efficiency and lowered carcass quality (Bell and Erhart, 1955; Bush, 1955; Davey *et al.*, 1956; Henneman *et al.*, 1957; Taylor *et al.*, 1957).

*Side Effects.* Other effects of the hormones were also noted in the feedlot and at the time of slaughter. There was some riding and also dribbling urine among the lambs in both hormone lots throughout the last two-thirds of the feeding period; neither of these effects was noticed in the control lot. The dripping of urine has also been observed by Hale *et al.* (1955) when 1.2 mg. stilbestrol was fed per pound of ration.

*Urogenital Tract.* From examination of the wethers at the time of slaughter it was apparent that the sexual organs which surround the urethra had enlarged slightly in the stilbestrol lambs and greatly in the implanted lambs, decreasing the size of the opening in the urethra. Urinary calculi or kidney stones, commonly a threat in feeding wether lambs, could be stopped more easily and urine flow could be blocked completely if the size

of the urethra is reduced. Three implanted lambs had been removed temporarily during the feeding period with apparent symptoms of urinary calculi. At the time of slaughter a calculus was found in the urinary tract of one control lamb and one or more calculi were found in four stilbestrol fed and four implanted lambs. Purulent cystitis was noted in two of the implanted lambs.

*Pelting.* Difficulty was experienced in removing the pelts from the implanted lambs. This was apparently due to the presence of an abnormal abundance of fibrous connective tissue immediately under the skin. When the pelts were removed, some of the fibrous tissue remained on the carcass and some remained on the pelts, resulting in heavier pelts. After the carcasses chilled, the fibrous tissue remaining on the carcass looked like a layer of fat, which might have resulted in higher U.S.D.A. carcass grades than were merited. Henneman *et al.* (1957) reported similar difficulty in pelting and also that when lambs were "topped out" at the choice grade on a live basis the carcasses of the implanted lambs graded consistently lower than controls. Perhaps the "feel" of choice finish among the implanted lambs was due to the presence of this fibrous tissue. In the study reported herein, experienced lamb buyers and salesmen estimated carcasses from the implanted lambs would grade much higher than carcasses from control lambs after they had been on feed 68 days, but the carcass grades of these implanted lambs were actually much lower.

*Wool.* Pelts from the five control and five implanted lambs killed earlier in the experiment were sheared and both the sheared pelts and wool were weighed. As can be noted in table 1, the implanted lambs yielded less wool, expressed as a percent of live weight. Severe shedding of wool was noted among these implanted lambs during the feeding period. Bell and Erhart (1955) reported fleece weights of lambs receiving this material were less than those of lighter control lambs.

*Experiment 2*

*Feedlot Data.* There was a slight but non-significant improvement in rate of gain, daily feed consumption, and feed efficiency among the lambs receiving ½ mg. stilbestrol per pound of ration (table 2). The stilbestrol lambs did consume significantly ($P<.05$) more water per day.

The reason for a small improvement in gains and feed efficiency as the result of feeding stilbestrol is not apparent. Assay of the experimental ration indicated the stilbestrol was thoroughly mixed and had maintained its potency. This experiment was conducted in the summer when the temperature was consistently over 100° F.

*Slaughter Data.* The stilbestrol-fed lambs had a considerably lower yield and therefore carcasses produced from lambs on the two treatments weighed essentially the same. As observed in Experiment 1, pelts were more difficult to remove from the stilbestrol lambs. The livers of the

TABLE 2. EFFECT OF STILBESTROL, FED TO PAIRED LAMBS, ON FEEDLOT PERFORMANCE, CARCASS MERIT AND PRODUCT QUALITY, EXPERIMENT 2

| Lot | Control | Stilbestrol (0.5 mg./lb. ration) |
|---|---|---|
| Feedlot data | | |
| No. lambs | 7 | 7 |
| Av. initial wt., lb. | 64.4 | 64.1 |
| Av. final wt., lb. | 90.5 | 94.0 |
| Av. daily gain, lb. | 0.40 | 0.43 |
| Feed per day, lb. | 3.46 | 3.65 |
| Feed per lb. gain, lb. | 8.74 | 8.63 |
| Water per day, ml. | 3933 | 4351[a] |
| Slaughter data | | |
| Cold carcass wt., lb. | 44.8 | 44.6 |
| Yield, %[b] | 49.5 | 47.9 |
| Cooler shrink, 2 days, % | 2.6 | 2.9 |
| Liver wt., gm. | 540 | 631 |
| Kidney wt., gm. | 94.3 | 88.9 |
| Ease of removing pelts[c] | 1.86 | 2.50[e] |
| Carcass grade[d] | 5.43 | 5.71 |
| Wt. of 9-rib racks, lb. | 5.00 | 5.08 |
| Edible portion, % | 79.17 | 80.35 |
| Inedible portion, % | 20.83 | 19.65 |
| Chemical analyses | | |
| Edible tissue of 9-rib racks | | |
| Moisture, % | 41.27 | 40.80 |
| Ether extract, % | 46.28 | 47.16 |
| Ash, % | 0.65 | 0.64 |
| Protein, % | 12.01 | 12.12 |
| Ash of fore shank bone, % | 57.93 | 60.31[f] |
| Cooking data | | |
| No. legs | 14 | 14 |
| Total cooking shrink, % | 25.9 | 26.0 |
| Evaporation, % | 16.4 | 17.0 |
| Liquid loss, % | 9.5 | 9.0 |
| Shear value, lb. | 4.24 | 4.22 |
| Organoleptic scores[g] | | |
| Juiciness | 2.51 | 2.54 |
| Tenderness | 2.99 | 3.14 |
| Flavor | 2.77 | 2.56[a] |
| Aroma | 2.81 | 2.82 |

[a] Significant at $P<0.05$.

[b] Yield $= \frac{\text{cold carcass wt.}}{\text{av. final wt.}} \times 100$.

[c] A score of 1=easy, 2=normal, 3=difficult, 4=very difficult.

[d] A score of 7=av. choice, 6=low choice, 5=high good, 4=av. good, 3=low good.

[e] Significant at $P=0.06$.

[f] Significant at $P<0.01$.

[g] A score of 3=desirable (moist, tender, mild); 2 or 1=too little (dry, mealy, tasteless); 4 or 5=too much (greasy, tough, strong).

stilbestrol lambs were significantly (P=.06) larger. Other recorded differences were small.

*Chemical Analyses.* The slightly lower moisture and protein content of the edible tissue from the racks of the stilbestrol lambs and the higher percentage of ether extract are in accord with the slightly higher carcass grade of these lambs. As the percentage of fat increases in a carcass the percentages of moisture and protein decline.

The protein analysis figures may be further evidence that the additional nitrogen reportedly retained during stilbestrol feeding may be used for the building of tissue other than muscle tissue (Whitehair *et al.*, 1953; Jordan, 1953; Thompson *et al.*, 1955; Struempler and Burroughs, 1956, 1957; Campbell *et al.*, 1956; Acker, 1957).

Nutrient retention studies provide an estimate of the relative amounts of a nutrient retained in the body, but do not disclose where that nutrient is deposited. Increased nitrogen retained as the result of stilbestrol administration might mean an increase in growth of any type of protein tissue in the body, such as lean muscle, connective tissue, epidermis, blood or wool. Clegg and Cole (1954) suggested the increased loin eye area among stilbestrol fed cattle would indicate that the increased nitrogen retained was being used to build muscle tissue. In this study, increased nitrogen retention was apparently associated with the build-up of connective tissue immediately under the skin of lambs. This is supported by the increased skin thickness noted in Experiment 1, and among stilbestrol implanted lambs reported by Wilkinson *et al.* (1950). Also Clegg and Carroll (1956) have reported that histological studies of the seminal vesicles indicated stilbestrol implantation of cattle stimulated the growth of epithelium and caused an increased development of fibrous tissue.

Shank bones from the stilbestrol lambs had a significantly higher percent ash (P<.01) than those from control lambs. This is in agreement with the work of Whitehair *et al.* (1953) and Thompson *et al.* (1955), indicating that stilbestrol increases the percent retention of calcium and phosphorus, and research of Shroder and Hansard (1958) showing that stilbestrol increased absorption of dietary calcium.

*Cooking Data.* Weight loss during roasting of the legs was not markedly different between treatments. These legs were from lambs that did not differ between treatments in rate of gain or cold carcass weight. Shear values, as a measure of tenderness, showed no consistent differences. Average scores of panel members for the organoleptic study indicated the samples from the stilbestrol lambs were slightly less tender and had significantly less flavor.

## Summary

The addition of 0.5 mg. stilbestrol per pound of ration appeared to cause about a 15% improvement in gains and feed efficiency of ewe and

wether lambs fattened in dry lot during the fall and winter. The same treatment had little effect, however, on lambs fed individually during the hot summer months. The stilbestrol fed lambs were more difficult to pelt, yielded 1 to 1.6 percentage units less, and 26% of the carcasses in Experiment 1 were classed as yearlings. Lambs implanted with 250 mg. progesterone and 10 mg. estradiol gained 44% faster on 29% less feed than the control lambs. These lambs were more difficult to pelt than stilbestrol fed lambs, yielded 1.5 percentage units less, and 59% of the carcasses were classed as yearlings. Side effects, such as riding, dribbling urine and urinary calculi were observed on both hormone treatments, and there was severe shedding among the implanted lambs.

Chemical analysis and cooking and organoleptic tests of cuts from paired lambs fed during the summer did not reveal any striking differences as the result of including 0.5 mg. stilbestrol per pound of ration.

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# PELLETED COMPLETE MIXED RATIONS FOR FEEDER LAMBS

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THE use of a pelleted complete mixed ration is an efficient method of controlling the ratios of the various ingredients one to another. Likewise, it is a valuable method of administering minute amounts of ingredients or ingredients that may not be palatable. Therefore, a pelleted ration for feeder lambs was developed in order more closely to control dosage levels of certain oral treatments. It was found that control lambs given no treatment other than the pelleted complete mixed ration grew more rapidly than expected and stayed on feed so well throughout the entire feeding trial that research was started to test several modifications of the original pellet.

The pelleting of rations for lambs is not new. Esplin *et al.* (1957) summarized pelleting trials from nine experiment stations using a variety of concentrates and roughages and various ratios of roughage to concentrate. However, in only one of the trials reported did the rate of gain equal 0.5 lb. per day. Since control lambs at this station consistently gained in excess of 0.5 lb. per day on an experimental pellet, it seemed desirable to study various modifications of the pellet and their subsequent effects on rates of gain, efficiency of feed utilization and quality of carcasses produced.

## Experimental Procedure

*Trial I.* One hundred forty-four western feeder lambs averaging 73 lb. were divided into six lots of 24 lambs each. All lots were fed *ad libitum* a complete mixed pelleted ration (table 1). This trial was designed to study the effect of incorporating either 7.5% yellow grease or 10% sugar alone or in combination into the pellet, or the effect of substituting dried skimmilk or fishmeal for the soybean meal as sources of protein. At the time of slaughter, dressing percentages and carcass grades were obtained.

*Trial II.* One-hundred eighty western feeder lambs averaging 75 lb. were divided into 12 lots of 15 lambs each. All lots were allowed *ad libitum* a complete mixed pelleted ration (table 2). This trial was designed to study the comparative value of a number of roughages (corn cobs, oat mill feed, soybean mill feed, sun cured alfalfa meal, sugar cane bagasse and cottonseed hulls) and two ratios of roughage to concentrate (60% roughage to 40% concentrate and 40% roughage to 60% concentrate).

[1] Contribution from the Department of Animal Science, Journal Paper No. 1398, Purdue University, Lafayette, Indiana.

TABLE 1. PERCENTAGE COMPOSITION OF RATIONS. TRIAL I

| Ingredient | Lot I Regular pellet | Lot II 7.5% Yellow grease | Lot III 10% Cane sugar | Lot IV 7.5% Grease 10% Sugar | Lot V 9% Skim milk | Lot VI 5.1% Fish meal |
|---|---|---|---|---|---|---|
| Ground corn cobs | 39.5 | 39.5 | 39.5 | 39.5 | 39.5 | 39.5 |
| Dehydrated alfalfa meal (17%) | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| Ground yellow corn | 32.0 | 24.5 | 22.0 | 14.5 | 30.0 | 33.9 |
| Stabilized yellow grease | .... | 7.5 | .... | 7.5 | .... | .... |
| Cane sugar | .... | .... | 10.0 | 10.0 | .... | .... |
| Soybean meal (44%) | 7.0 | 7.0 | 7.0 | 7.0 | .... | .... |
| Skimmilk (34%) | .... | .... | .... | .... | 9.0 | .... |
| Menhaden fish meal (60%) | .... | .... | .... | .... | .... | 5.1 |
| Iodized salt[a] | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Steamed bonemeal | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Vitamin A concentrate[b] | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 |

[a] One ounce of cobalt carbonate per 100 lb. of salt.
[b] Provides 3400 units of vitamin A per lb. of ration.

## Results and Discussion

In both trials the control lambs fed the pellet containing approximately 40% ground corn cobs and 20% dehydrated alfalfa meal (60% roughage) gained slightly more than 0.50 lb. per day. The replacement of 7.5% of corn with 7.5% of stabilized yellow grease (Trial I, Lot II) or the lowering of roughage and increasing the concentrate (Trial II, Lots VII through XII) actually resulted in a highly significant decrease in the rate of gain. Apparently, added energy did not improve the growth promoting powers of the pelleted complete mixed ration. In Trial II, however, when the six kinds of roughages were grouped together under one level (60% roughage) and compared with the same roughages under another level (40% roughage), there was significant interaction between kind of roughage and level of roughage. It was apparent that level of roughage was not of too much importance in the case of ground corn cobs, sugar cane bagasse or cottonseed hulls, but level of roughage was a factor in the case of oat mill feed, soy mill feed and sun cured alfalfa.

Much speculation has been made as to what controls the feed consumption of animals. It will be noted from tables 2 and 4 that the lots which gained less (higher energy pellets) than the lot on the control pellet consumed much less feed per day—as much as 22% less per day. Possibly level of energy may be one of the factors that determine how many pounds of feed an animal will eat in a day. The data in this paper suggest that that would be the case with feeder lambs. Hartman *et al.* (1958) reported no difference in rate of gain between lots of lambs on pellets containing 71% concentrate and 29% roughage as compared to 41% concentrate and 59% roughage. However, the ratios of concentrate to roughage in their

TABLE 2. PERCENTAGE COMPOSITION OF RATIONS. TRIAL II

| Ingredient | 60% Roughage: 40% Concentrate | | | | | | 40% Roughage: 60% Concentrate | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lot I Corn cobs | Lot II Oat mill feed | Lot III Soy mill feed | Lot IV Sun-cured alfalfa | Lot V Sugar-cane bagasse | Lot VI Cotton-seed hulls | Lot VII Corn cobs | Lot VIII Oat mill feed | Lot IX Soy mill feed | Lot X Sun-cured alfalfa | Lot XI Sugar-cane bagasse | Lot XII Cotton-seed hulls |
| Ground corn cob | 40 | .. | .. | .. | .. | .. | 20 | .. | .. | .. | .. | .. |
| Oat mill feed | .. | 40 | .. | .. | .. | .. | .. | 20 | .. | .. | .. | .. |
| Soy mill feed | .. | .. | 40 | .. | .. | .. | .. | .. | 20 | .. | .. | .. |
| Sun-cured alfalfa | .. | .. | .. | 40 | .. | .. | .. | .. | .. | 20 | .. | .. |
| Sugar-cane bagasse | .. | .. | .. | .. | 40 | .. | .. | .. | .. | .. | 20 | .. |
| Cottonseed hulls | .. | .. | .. | .. | .. | 40 | .. | .. | .. | .. | .. | 20 |
| Dehydrated alfalfa | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Ground yellow corn | 29.5 | 29.5 | 36.5 | 36.5 | 28.5 | 31.5 | 52.5 | 52.5 | 56.5 | 56.5 | 52.5 | 53.5 |
| Soybean meal | 7 | 7 | .. | .. | 8 | 5 | 4 | 4 | .. | .. | 4 | 3 |
| Molasses distillers solubles | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Bonemeal | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Iodized salt | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Calculated analysis: [a] | | | | | | | | | | | | |
| Digestible protein | 10.1 | 10.1 | 11.4 | 12.2 | 10.0 | 10.1 | 10.3 | 10.3 | 10.7 | 12.2 | 10.0 | 10.1 |
| T.D.N. | 58.2 | 54.6 | 52.9 | 59.9 | ? | 57.5 | 74.5 | 63.4 | 63.5 | 66.0 | ? | 64.7 |
| Crude fiber | 17.9 | 18.5 | 20.1 | 17.6 | 23.7 | 24.0 | 12.5 | 12.8 | 15.0 | 12.2 | 15.4 | 15.6 |
| Ca | 0.6 | 0.7 | 0.6 | 1.2 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.9 | 0.6 | 0.6 |
| P | 0.3 | 0.3 | 0.3 | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.3 | 0.3 |

[a] N.R.C. recommendations (1957) 80 lb. fattening lamb; digestible protein, 10.3%; T.D.N., 62%; calcium, 0.19%; phosphorus, 0.17%.

pelleted rations were not comparable to these. Bell *et al.* (1955) reported lambs fed low levels of grain did not gain as rapidly as lambs fed high levels of grain (35% corn vs. 45% corn).

The addition of 10% sugar did not alter consumption or rate of gain. A combination of 7.5% yellow grease and 10% sugar did not improve the pellet. This combination as a replacement for corn or the replacement of soybean meal with a protein equivalent amount of either dried skimmilk or menhaden fish meal resulted in a statistically significant ($P<0.05$) decrease in rate of gain (Trial I, table 2). Jordan *et al.* (1958) reported no growth depressant effect from including 10% of stabilized tallow to a

TABLE 3. RESULTS OBTAINED WITH DIFFERENT SOURCES OF ENERGY AND PROTEIN IN A FEEDER LAMB PELLET

(November 1, 1956 to January 7, 1957—76 days)

| Item | Lot I Regular pellet | Lot II 7.5% Yellow grease | Lot III 10% Cane sugar | Lot IV 7.5% Grease 10% Sugar | Lot V 9% Skim milk | Lot VI 5.1% Fish meal |
|---|---|---|---|---|---|---|
| No. lambs | 24 | 24 | 24 | 24 | 24 | 24 |
| Initial wt., lb. | 74 | 72 | 72 | 72 | 73 | 72 |
| Final wt., lb. | 109 | 100 | 108 | 102 | 104 | 102 |
| Total gain, lb.* | 35 | 27 | 36 | 30 | 31 | 30 |
| Daily gain, lb. | 0.53 | 0.40 | 0.54 | 0.45 | 0.47 | 0.44 |
| Pellets, daily, lb. | 4.1 | 3.5 | 4.0 | 3.5 | 3.9 | 3.5 |
| Pellets/100 lb. gain, lb. | 758 | 873 | 747 | 771 | 827 | 797 |
| Dressing % | 47.6 | 47.8 | 48.6 | 47.9 | 48.7 | 45.2 |
| U. S. Choice, no. | 14 | 13 | 13 | 7 | 13 | 8 |
| U. S. Good, no. | 10 | 11 | 11 | 16 | 11 | 16 |
| Utility, no. | .... | .... | .... | 1 | .... | .... |

* Least significant difference for gain: 5%, 3.95 lb.; 1%, 5.2 lb.

soybean oil supplement for fattening lambs. However, Hale *et al.* (1954) reported lowered feed consumption and decreased rate of gain from adding either 5% or 9% fat in a practical lamb fattening ration. In a later report, Hale *et al.* (1956) reported that 3% added fat resulted in slightly increased feed intake and growth rate.

It is apparent from the data that ratio of roughage to concentrate (Trial II, table 4) affects the comparative value of the six roughages tested. Ground corn cobs were not surpassed as the principal source of roughage. Therefore, the comparisons are in terms of how well the other five roughages measured up to ground corn cobs. Lambs fed the pellet in which oat mill feed comprised the principal source of roughage (Lot II) were the only lambs which gained less ($P<0.05$) than the controls (Lot I), of the six lots on the 60% roughage to 40% concentrate ration. However, on

TABLE 4. RESPONSE OF LAMBS TO VARIOUS ROUGHAGES AND TWO RATIOS OF ROUGHAGE TO CONCENTRATE

(November 11, 1958 to January 19, 1959—69 days)

| Item | 60% Roughage: 40% Concentrate | | | | | | 40% Roughage: 60% Concentrate | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lot I Corn cobs | Lot II Oat mill feed | Lot III Soy mill feed | Lot IV Sun-cured alfalfa | Lot V Sugar-cane bagasse | Lot VI Cotton-seed hulls | Lot VII Corn cobs | Lot VIII Oat mill feed | Lot IX Soy mill feed | Lot X Sun-cured alfalfa | Lot XI Sugar-cane bagasse | Lot XII Cotton-seed hulls |
| No. of lambs | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Initial wt., lb. | 75 | 76 | 75 | 75 | 75 | 76 | 76 | 77 | 76 | 76 | 75 | 76 |
| Final wt., lb. | 111 | 104 | 106 | 106 | 106 | 109 | 110 | 100 | 101 | 98 | 107 | 110 |
| Total gain, lb.* | 36 | 28 | 31 | 31 | 31 | 33 | 34 | 23 | 25 | 22 | 32 | 34 |
| Average daily gain, lb. | 0.52 | 0.42 | 0.44 | 0.44 | 0.44 | 0.48 | 0.50 | 0.33 | 0.36 | 0.32 | 0.46 | 0.50 |
| Pellets, daily, lb. | 4.0 | 4.3 | 3.6 | 4.0 | 3.7 | 4.8 | 3.8 | 3.2 | 3.1 | 3.1 | 3.8 | 4.1 |
| Pellets/100 lb. gain, lb. | 776 | 1042 | 800 | 905 | 840 | 989 | 760 | 990 | 869 | 960 | 820 | 832 |
| Dressing, % | 52.2 | 49.4 | 48.4 | 50.2 | 48.4 | 53.1 | 55.1 | 48.8 | 50.7 | 48.0 | 54.4 | 55.6 |
| U. S. Choice, no. | 11 | 9 | 13 | 10 | 11 | 13 | 12 | 12 | 12 | 12 | 15 | 14 |
| U. S. Good, no. | 4 | 6 | 3 | 5 | 4 | 2 | 3 | 3 | 3 | 3 | .. | 1 |

* LSD for gain: 5%, 4.88 lb.; 1%, 6.44 lb.

the 40% roughage to 60% concentrate ration, lambs whose principal source of roughage was oat mill feed (Lot VIII), soybean mill feed (Lot IX) or sun cured alfalfa meal (Lot X) gained less ($P<0.01$) than lambs on the cob control ration (Lot VII). Ratio of roughage to concentrate did not affect rates of gain significantly in the cases of sugar cane bagasse or cottonseed hulls as sources of roughages.

The first six lots of lambs (Trial II) on the high roughage pellet gained more ($P<0.01$) than the last six lots on the low roughage pellet. It seems apparent that the optimum level of concentrate which should be fed for maximum gain is relatively low.

Carcass grade was not appreciably affected in Trial I by any of the treatments. However, in Trial II there was a trend toward improved carcasses in the slower gaining lambs whose rations contained the higher level of concentrates.

Dressing percentage tended to reflect rate of gain, i.e., the faster gaining lambs had a greater average dressing percent with either of the roughage levels tested. However, lambs fed the lower roughage pellet and which gained less rapidly ($P<0.01$) than lambs fed the higher roughage pellet had a higher dressing percent (50.3% average for Lots I through VI vs. 52.1% for the last six lots).

## Summary

Two feeding trials were conducted with western lambs to evaluate several modifications of a pelleted complete mixed ration consisting of ground corn cobs, 39.5; dehydrated alfalfa meal, 20; ground yellow corn, 32; soybean oil meal, 7; iodized salt, 0.5; steamed bonemeal, 1.0; and vitamin A.

A significant decrease in gain was obtained for incorporating 7.5% of stabilized yellow grease alone ($P<0.01$) or in combination with 10% of cane sugar ($P<0.05$) in place of corn, or replacement of soybean meal with a protein equivalent of dried skimmilk or menhaden fish meal ($P<0.05$).

Lambs whose pellets contained a ratio of 60% roughage to 40% concentrate grew more rapidly ($P<0.01$) than those whose ratio was 40% roughage to 60% concentrate.

Oat mill feed, soybean mill feed and sun cured alfalfa meal were not so valuable as principal sources of roughage ($P<0.05$) as ground corn cobs, sugar cane bagasse or cottonseed hulls.

Even though lambs fed the 40% roughage pellet gained less rapidly ($P<0.05$), the dressing percent was greater (50.3% for 60% roughage lots vs. 52.1% for 40% roughage lots) than for the more rapid-gaining lambs fed the 60% roughage pellet.

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# THE MUSCLE-BONE RELATIONSHIP IN BEEF [1, 2]

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WITH the changes in market demands, there has been more and more emphasis placed on inherent muscling and freedom from excessive fatness in beef. Therefore, an objective index of muscling either in the live animal or carcass would be extremely useful. The cannon bones have been studied as to their possible relationship to early maturity and degree of muscling. Hammond (1932) and Palsson (1939, 1940) reported that thickness of bone is directly associated with breed improvement for increased meat production and early maturity. Hirzel (1939) reported that shortening and thickening of the cannon is associated with a thickening and shortening of muscle covering in sheep. Concerning the cannon bone: muscle ratio, McMeekan (1956) stated, "So strong is this relationship that the weight of muscle could be determined within one percent if the weight of the cannon bones are known." He also stated that the finer boned animals have a smaller amount of lean tissue and a larger amount of fat than the heavier boned animals on a percentile basis. The data of Wythe (1958) on 28 steers indicated that a significant positive relationship existed between bone thickness and muscling.

The use of measurements taken of the spinal processes as a possible index to muscling has been investigated previously. Ljungdahl (1942) measured the spinous processes of the shoulder, rack and loin of lambs and found that the lengths of the several processes were not closely related to the weights of the respective wholesale cut.

This study was undertaken to determine the usefulness of using various measurements of cannon bones and those taken from radiographs of the lumbar region of the vertebrae as a possible index to total muscling in beef cattle.

## Materials and Methods

Thirty-one steers consisting of 8 Angus and 23 Herefords from the Michigan State University beef cattle breeding project supplied the data presented here.

*Cannon Bones.* The metacarpals and metatarsals were taken from the steers at the time of slaughter, cleaned of all extraneous material, weighed,

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[2] This paper reports a portion of the Ph.D. thesis presented by the senior author to the School for Advanced Graduate Studies at Michigan State University.

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[4] This study was conducted in cooperation with the North Central Regional Project NC–1, The Improvement of Beef Cattle Through Breeding Methods.

and the following measurements taken: *length* as measured from the articular surface of the medial portion of the proximal end to a point medial of the sagittal ridge of the third condyle; *width, thickness* and *circumference* at a point one-half the distance of the length (figure 1).

*Radiographs of Lumbar Vertebra.* Radiographs of the shortloin were taken of both dorsal and lateral views.

*Dorsal View.* Radiographs were taken using a setting of 74KV for a time of 3/20 second and at a distance of 40 inches from the unsplit or

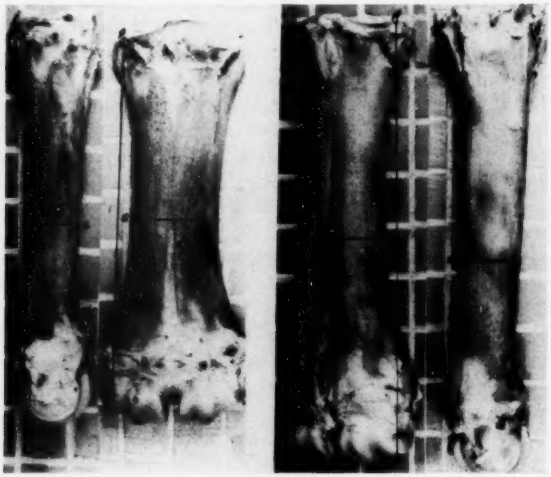

**Figure 1**

| Fore Cannon | Hind Cannon |
|---|---|
| a) Length | a) Length |
| b) Width and circumference | b) Width and circumference |
| c) Thickness | c) Thickness |

double shortloin, depicting the length and width of the transverse processes and the length and width of the body of the vertebra. Figure 2 shows a radiograph taken of the dorsal view of the unsplit shortloin and the points at which the measurements were taken. *Length* of *transverse processes* was the distance from the lateral tip of the left transverse process to the lateral tip of the right transverse process. (This measurement included the length of both lateral transverse processes and the width of the vertebra body.) *Width* of *transverse processes* was taken at a point 20% the total length of the transverse processes and on a line parallel to a line drawn along the lateral tips of the body of the vertebra. *Area* of *transverse processes* was taken by use of a planimeter, and included the area within the margin of each right transverse process. *Vertebra length* was the distance between the most anterior portion of the convex surface

to the most anterior concave surface of the vertebra body. Width of vertebra was taken at a point where the body of the vertebra was narrowest.

*Lateral View.* In order to obtain radiographs of the lateral view, the double short loins were sawed in half longitudinally and a setting of 90KV for ½ second at a distance of 40 inches was used. The following three measurements were taken from the X-rays of the lateral view (figure 3): *Length* of *vertical processes* was the distance between the tip of the spinous process and an arbitrary line, which was drawn between two points located at the dorsal tip of the vertebra body. *Height* of *anterior articular processes*

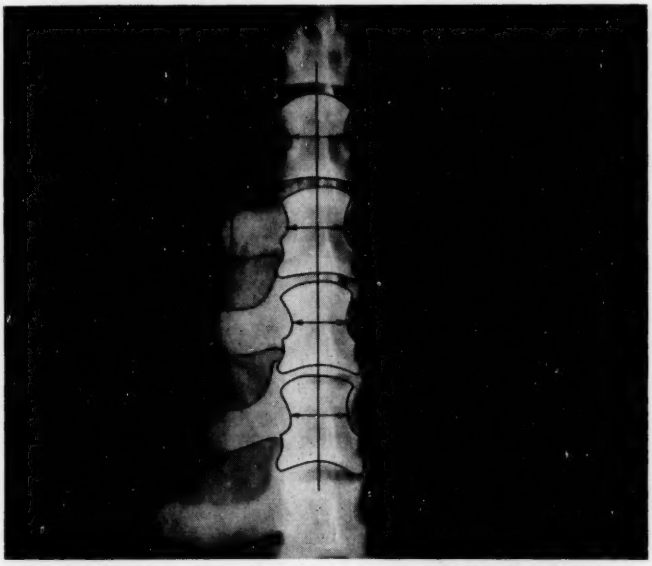

**Figure 2. Dorsal view of lumbar vertebra.**

was the distance from the arbitrary line to the most dorsal point of the anterior articular process. *Width* of *vertical processes* was taken at a point 60% the distance from the arbitrary line to the tip of the spinous process and on a line parallel to the base line. Six radiographs of the laterial view depicting the length and width of the vertical processes were not differentiated sufficiently for measurements to be taken.

All linear measurements of the cannon and of the radiographs of the lumbar vertebra were taken in millimeters. Weights of the cannons were taken to the nearest gram; whereas, area of the transverse processes was recorded in square inches.

*Slaughter and Carcass Data.* Every steer was weighed before slaughtering to obtain the slaughter weight. The chilled carcass weight was obtained

by weighing each unsplit carcass 48 hours after slaughter. After an aging period of 8 days at 32–34° F. the left side of each carcass was cut into wholesale cuts according to the procedure recommended by Hankins and Howe (1946) and outlined later by Wellington (1953), except that a conventional square chuck was cut. The area of rib-eye was obtained by tracing the *Longissimus dorsi* muscle at the 12th rib and later measuring the tracing with a planimeter. The 9–10–11 rib sections were excised from each wholesale rib as described by Hankins and Howe (1946), and separable lean, fat and bone determined. The separable lean in the 9–10–11

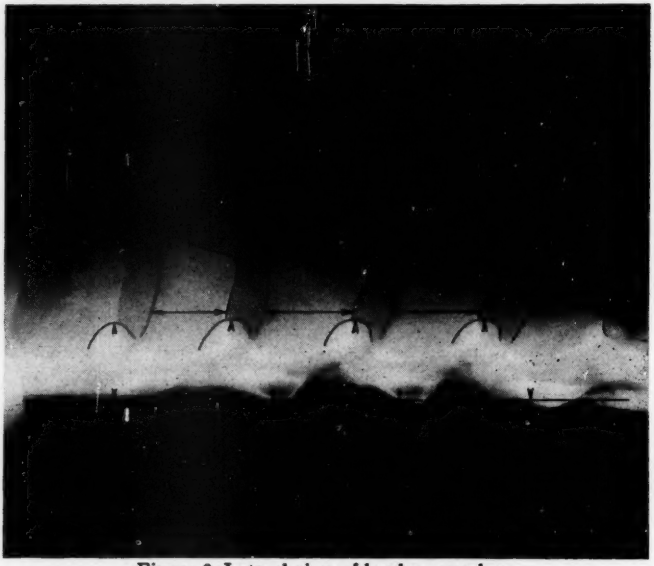

**Figure 3. Lateral view of lumbar vertebra.**

rib cut was used to estimate the total carcass lean, using the regression equation $Y=15.56+.81X$ reported by Hankins and Howe (1946).

*Statistical Analysis.* Simple and multiple correlation coefficients and standard partial regression coefficients were employed as given by Snedecor (1946). All analyses were made on a within year basis to eliminate any effect of years.

## Results and Discussion

Correlation coefficients were calculated (table 1) between the various cannon bone measurements with chilled carcass weight, weight and percent of primal cuts, and estimated weight and percent of carcass lean. The rib, shortloin, sirloin and round were included as primal cuts.

TABLE 1. SIMPLE AND MULTIPLE CORRELATIONS AND STANDARD PARTIAL REGRESSION COEFFICIENT OF VARIOUS CANNON BONE MEASUREMENTS WITH CHILLED CARCASS WEIGHT, WEIGHT AND PERCENT OF PRIMAL CUTS, AND WEIGHT AND PERCENT OF ESTIMATED CARCASS LEAN

| X | r Chilled carcass wt. with | r Primal cut | | b'[a] | | R Primal cut with carcass wt. | | r Estimated carcass lean | | b'[b] | | R Estimated carcass lean with carcass wt. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Wt. with | % with | Wt. | % | Wt. and | % and | Wt. with | % with | Wt. | % | Wt. and | % and |
| Fore cannon | | | | | | | | | | | | | |
| Weight | 0.60** | 0.62** | 0.19 | 0.29 | 0.68 | 0.75** | 0.68** | 0.66** | 0.00 | 0.30 | 0.47 | 0.82** | 0.63** |
| Length | 0.52** | 0.68** | 0.37* | 0.42 | 0.80 | 0.80** | 0.80** | 0.64** | 0.01 | 0.32 | 0.37 | 0.83** | 0.59** |
| Width | 0.48** | 0.53** | 0.29 | 0.24 | 0.63 | 0.75** | 0.69** | 0.57** | 0.00 | 0.25 | 0.31 | 0.81** | 0.57** |
| Thickness | 0.42* | 0.45** | 0.05 | 0.18 | 0.27 | 0.74** | 0.48* | 0.67** | 0.02 | 0.42 | 0.28 | 0.87** | 0.56** |
| Circumference | 0.22 | 0.17 | 0.33 | 0.01 | 0.44 | 0.72** | 0.60** | 0.15 | 0.02 | —.02 | 0.14 | 0.78** | 0.52** |
| Hind cannon | | | | | | | | | | | | | |
| Weight | 0.63** | 0.65** | 0.16 | 0.33 | 0.69 | 0.77** | 0.68** | 0.69** | —.01 | 0.33 | 0.51 | 0.82** | 0.64** |
| Length | 0.47** | 0.61** | 0.35* | 0.35 | 0.70 | 0.79** | 0.74** | 0.57** | 0.01 | 0.26 | 0.31 | 0.81** | 0.57** |
| Width | 0.40* | 0.43* | 0.24 | 0.17 | 0.48 | 0.74** | 0.60** | 0.56** | 0.01 | 0.30 | 0.25 | 0.83** | 0.55** |
| Thickness | 0.64** | 0.52** | 0.04 | 0.10 | 0.51 | 0.73** | 0.57** | 0.76** | 0.00 | 0.44 | 0.54 | 0.85** | 0.65** |
| Circumference | 0.55** | 0.48** | 0.15 | 0.12 | 0.54 | 0.73** | 0.61** | 0.63** | 0.00 | 0.29 | 0.39 | 0.82** | 0.60** |
| Carcass weight | .... | 0.72** | —.41* | .... | .... | .... | .... | 0.78** | —.50** | .... | .... | .... | .... |

[a] Standard partial regression coefficient of weight or percent of primal cuts on X when weight is held constant.
[b] Standard partial regression coefficient of weight or percent of estimated carcass lean on X when weight is held constant.
* Significance at P=0.05.
** Significance at P=0.01.

All correlation coefficients between cannon measurements and the weight of the chilled carcass were highly significant except thickness and circumference of fore cannon and width of hind cannon. Weight of either the hind or fore cannon or the thickness of the hind cannon was associated with 36 to 41% of the variation in the weight of the chilled carcass. As shown in table 1, all correlation coefficients between the weight of primal cuts and various linear measurements of the fore and hind cannons were highly significant, except for circumference of the fore cannon and the width of the hind cannon. The weight and length of either the fore and hind cannons appeared to give the best estimate of weight of primal cuts. All relationships were positive. When the same measurements were correlated with percent of primal cuts, only the length of either the fore or hind cannon was directly and significantly related to percent primal cuts. This agrees with Ljungdahl (1942) who found that the longer legged lambs tended to have a higher percent of leg, even though the carcasses from such lambs graded lower.

The estimate of the weight of lean and percent of lean in the carcass was compared with the various cannon bone measurements. The correlation coefficients appear in table 1. With the exception of circumference of fore cannon, all correlation coefficients between the measurements of the cannons and estimated weight of carcass lean were highly significant and directly related, being associated with 32 to 58% of the variation in estimated carcass lean. However, when the percent of estimated carcass lean was correlated with the various cannon bone measures all correlation coefficients approached zero.

Since carcass weight is negatively associated with percent primal cuts but positively associated with cannon bone measurements, it was deemed advisable to consider the relationship between cannon measurements and percent primal cuts free from the effects of carcass weight. The values of the standard partial regression coefficients in table 1 show that for the same weight, steers with the greater amount of bone tended to have the higher percent of primal cuts. Percent primal cuts appears to be more closely associated with length of cannon than with any other measure taken. With regard to the relationship between amount of bone and estimated percent of carcass lean, there was a slight tendency for steers with more bone to have a higher percent of carcass lean but the association was too low to be of value in predicting carcass lean from cannon bone measurements.

The correlation coefficients obtained between ribeye area and the various cannon bone measurements were not statistically significant (table 2).

Positive correlation coefficients were obtained in all instances when the various measurements of either the fore or hind cannons were correlated to the weight of the live animal. Therefore, larger cannon bone measurements were related to increased body size. The weight and width of either

TABLE 2. SIMPLE AND MULTIPLE CORRELATION COEFFICIENTS OF RIBEYE AREA WITH LIVE WEIGHT AND VARIOUS MEASUREMENTS OF THE FORE AND HIND CANNON BONES, AND STANDARD PARTIAL REGRESSION COEFFICIENTS WITH LIVE WEIGHT CONSTANT

| X | r Ribeye area with | r Live weight | b'[a] | R Ribeye area with live weight and |
|---|---|---|---|---|
| Fore cannon | | | | |
| Weight | 0.07 | 0.67** | —.34 | 0.45* |
| Length | —.11 | 0.61** | —.54 | 0.57** |
| Width | —.11 | 0.58** | —.50 | 0.55** |
| Thickness | 0.14 | 0.45* | —.04 | 0.38 |
| Circumference | —.20 | 0.36* | —.39 | 0.52** |
| Hind cannon | | | | |
| Weight | 0.16 | 0.68** | —.18 | 0.40 |
| Length | —.05 | 0.55** | —.37 | 0.49* |
| Width | —.18 | 0.51** | —.50 | 0.58** |
| Thickness | 0.23 | 0.66** | —.03 | 0.38 |
| Circumference | —.04 | 0.59** | —.40 | 0.50* |
| Combined weight of fore and hind cannons | 0.12 | 0.68** | —.26 | 0.42 |
| Live weight | 0.38* | .... | ..... | .... |

[a] Standard partial regression of ribeye area on X with weight held constant.
* Significance at P=0.05.
** Significance at P=0.01.

the fore or hind cannons along with thickness, length or circumference of the hind cannon were associated with 30 to 46% of the variation which existed in live animal weight. This showed that a direct relationship existed between weight of the animal and most cannon bone measurements.

Standard partial regression coefficients were calculated to eliminate the effect of live animal weight on the relationship between ribeye size and various cannon bone measurements. With the effect of live weight removed, the width, length and circumference measurements of the fore and hind cannons gave the best estimates of ribeye size, accounting for 15–25 percent of the variation in ribeye area (table 2). All relationships were negative, thus indicating in cattle of the same weight that there is a tendency for the larger ribeye areas to be associated with the shorter, finer and lighter cannons. In order to predict ribeye area from cannon bone measurements, partial regression coefficients were calculated. The partial regression coefficients for ribeye area on length of fore cannon and live weight are —.059 and 0.008, respectively. The partial regression coefficients for ribeye area on width of hind cannon are —.222 and 0.007, respectively.

The Angus steers tended to have smaller cannon bone measurements

than the Herefords; therefore, the relationship of both cannon bone measurements and live weight with ribeye area were calculated on a within breed-year group basis. The correlation coefficients calculated on this basis between the various cannon bone measurements and either ribeye area or live weight tended to increase. The standard partial regression coefficients of ribeye area on cannon bone measurements tended to be near zero while those for ribeye area on live weight tended to increase.

TABLE 3. SIMPLE AND MULTIPLE CORRELATION COEFFICIENTS OF RIBEYE AREA WITH LIVE WEIGHT AND VARIOUS AVERAGE LUMBAR VERTEBRA MEASUREMENTS. ALSO STANDARD PARTIAL REGRESSION COEFFICIENTS WITH LIVE WEIGHT CONSTANT

| X | r Ribeye area with | r Live weight with | b'[a] | R Ribeye area with live weight and |
|---|---|---|---|---|
| Dorsal view | | | | |
| Length of transverse processes | —.06 | 0.44* | —.29 | 0.46* |
| Width of transverse processes | —.32 | 0.26 | —.45 | 0.58** |
| Area of transverse processes | —.03 | 0.16 | —.09 | 0.39 |
| Vertebra length | 0.00 | 0.47** | —.23 | 0.43 |
| Vertebra width | 0.47** | 0.10 | 0.44 | 0.58** |
| Lateral view | | | | |
| Length of vertical processes[b] | 0.22 | 0.23 | 0.14 | 0.40 |
| Width of vertical processes[b] | —.45* | 0.04 | —.47 | 0.59** |
| Height of anterior articular processes[c] | —.24 | 0.40* | —.46 | 0.57** |
| Length of transverse processes times length of vertical processes | 0.10 | 0.34 | —.03 | 0.38 |
| Live weight | 0.38 | .... | ..... | .... |

[a] Standard partial regression of ribeye area on X with weight held constant.
[b] Only measurements taken of 25 radiographs.
[c] Only measurements taken of 30 radiographs.
* Significance at P=0.05.
** Significance at P=0.01.

The net effect was that the multiple correlation between ribeye area and the combined effect of cannon bone measurements and live weight was essentially unchanged when the effect of breeds was considered.

Multilinear correlation coefficients between ribeye area and live animal weight and the various measures of the cannons indicate that from 11 to 33% of the variation in ribeye area was associated with the independent variables. Live animal weight combined with either width or circumference gave the highest values.

The correlation coefficients listed in table 3 show that little, if any,

relationship existed between the various radiographic measurements taken of the lumbar vertebra and the area of the ribeye muscle. Width of both the vertebra and of the vertical processes showed the greatest relationship, having correlations with ribeye area of 0.47 and —.45, respectively.

Standard partial regression coefficients were calculated in order to remove any effect which live weight might have on the relationship of ribeye area to the various measures of the lumbar vertebra. With live weight constant, the vertebra width, the width of either the transverse or the vertical processes and the height of the anterior articular processes were all equal for predicting ribeye area, being associated with 18 to 21% of the variation. However, these equations showed an inverse relationship to ribeye area with the exception of the vertebra width.

TABLE 4. SIMPLE CORRELATION COEFFICIENTS BETWEEN VARIOUS MEASURMENTS OF TRANSVERSE PROCESSES OF THE LUMBAR VERTEBRA WITH CANNON BONE WEIGHT AND WEIGHT OF BONE AND PERCENT BONE IN 9–10–11 RIB SECTION [a]

| Item | Weight of cannon bones with | Weight of bone in 9–10–11 rib section with | Percent bone in 9–10–11 rib section with |
|---|---|---|---|
| Length of transverse processes | 0.81 | 0.34 | 0.25 |
| Width of transverse processes | 0.66 | 0.37 | 0.43 |
| Area of transverse processes | 0.66 | 0.27 | 0.13 |
| Vertebra length | 0.54 | 0.34 | 0.32 |
| Vertebra width | 0.04 | 0.10 | 0.07 |

[a] 0.35 required for significance at P=0.05.
0.45 required for significance at P=0.01.

Multiple correlations of ribeye size with live weight and the various lumbar measurements are also listed in table 3. The best combinations for predicting ribeye area were obtained by combining live weight with width of transverse processes, vertebra width, width of vertical processes or the height of the anterior articular processes. These joint effects were associated with 32 to 36% of the variation in area of ribeye.

Since both cannon bone weights and measurements and lumbar vertebra radiographic measurements were related to ribeye area, the question arose as to the relationship of the two different types of bone measurements to each other. In view of this, correlations were calculated between weight of cannons and the various linear measurements taken from the X-rays of the transverse processes of the lumbar vertebra. All correlation coefficients between the various measurements and the weight of the cannon bones were highly significant with the exception of width of vertebra (table 4). Thus, it appeared that the relationship between the various measurements of the lumbar vertebra was more highly associated with the total weight of the cannons than with the area of ribeye.

Table 4 lists the correlation coefficients of the measurements of the transverse processes with both weight and percent of bone in the 9–10–11 rib section. With the exception of width of the transverse processes all relationships were found to be insignificant.

## Summary

Live animal weight, chilled carcass weight, primal cut weight, and estimated carcass lean in almost all instances were significantly and positively related to the weights and various linear measurements of the fore and hind cannon bones. On the other hand, the association with the cannon bone measurements and primal cuts and estimated carcass lean were greatly reduced when calculated on a percentile basis. When the effects of live weight were held constant, width and circumference measurements of the hind and fore cannons were associated with 15 to 25% of the variation existing in ribeye area. The joint effects of live weight and each of the cannon bone measurements considered separately, accounted for only 14 to 34% of the variation in ribeye area.

Radiographic measurements of the dorsal and lateral view of the lumbar vertebra disclosed that width of the body of the lumbar vertebra and width of the vertical processes were the measurements most closely associated with ribeye area, accounting for 22 and 20% of the variation in ribeye area, respectively. When the effects of live weight were held constant, width of the transverse processes and height of the anterior articular processes were equal to the two previous measurements in predicting ribeye area. The joint effects of live weight and each of these four measurements of the lumbar vertebra explains only 32 to 36% of the variation existing in ribeye area.

Results indicate that both cannon bone measurements and radiographs of the lumbar vertebra are related to muscling. However, the relationships are not high enough to be useful for predictive purposes.

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# HYPOGLYCEMIC COMPOUNDS AS APPETITE STIMULANTS FOR BABY PIGS [1]

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THE observations of Bulatao and Carlson (1924), Mayer and Bates (1951), Mayer *et al.* (1952), Quigley *et al.* (1929), Stunkard and Wolff (1954), Stunkard *et al.* (1955), and Van Itallie *et al.* (1953), that a causal relationship seemed to exist between blood glucose and food intake, led to the glucostatic theory, which postulates an inverse relationship between the concentration of glucose in the blood and food intake.

The purpose of this study was to determine if feed consumption could be stimulated in the baby pig by experimental hypoglycemia. Tolbutamide, a sulfonylurea compound, and insulin were the two hypoglycemic agents used.

## Experimental

Baby pigs weaned at two weeks of age were used in this series of eight experiments. Feed and water were supplied to the pigs *ad libitum*. The composition of the basal rations is shown in table 1. Basal ration A was used in Experiments I and II and basal ration B in Experiments IV, V and VI. In Experiments VII and VIII basal ration B was slightly modified; dried whey was substituted for the rolled oats. The breeds of pigs used were: Hampshire, Spotted Poland China, Duroc, Yorkshire, Berkshire, Landrace, and various crosses of these breeds. The baby pigs were allotted to their respective treatments by weight and litter, or by weight and outcome groups. Each animal was weighed and the feed consumed by the animals in each treatment was determined at weekly intervals.

Blood glucose was determined at specific intervals by the method of Folin and Malmros (1929). Two blood samples were drawn with 0.1-ml. pipettes from the marginal blood vessels of the ear of each animal and duplicate determinations performed on each sample. An average of the four values represents the blood glucose concentration of each pig and is reported as mg. of glucose per 100 ml. of blood.

In Experiments IV and VI liver samples were obtained by biopsy and analyzed for glycogen by the method outlined by Good, Kramer, and Somogyi (1932); results are reported as percentage of glycogen in the weight of the liver sample.

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TABLE 1. COMPOSITION OF BASAL RATIONS

| Ingredient | Ration A | Ration B |
|---|---|---|
| | % | % |
| Ground yellow corn | 39.1 | 45.3 |
| Soybean meal (44%, solvent) | 18.7 | 32.0 |
| Dried skimmilk | 20.0 | .... |
| Rolled oats | 5.0 | 5.0 |
| Pure cane sugar | 10.0 | 10.0 |
| Lard | 3.0 | 3.0 |
| Ground limestone | 0.6 | 0.8 |
| Steamed bonemeal | 1.0 | 1.3 |
| Trace minerals[a] | 0.1 | 0.1 |
| Iodized salt | 0.5 | 0.5 |
| Vitamin and antibiotic premix[b] | 2.0 | 2.0 |

[a] Trace mineral premix for swine supplied by the Calcium Carbonate Co., Chicago, Illinois.
[b] Contained vitamin A (10,000 I.U./gm.), 14.0 gm.; vitamin D (4 M I.U./lb.), 4.5 gm.; Pfizer vitamin supplement No. 2, 6.8 gm. (contained 4,000 mg. riboflavin, 4,000 mg. pantothenic acid, 24,000 mg. niacin and 90,063 mg. choline chloride per lb.); niacin, 0.9 gm.; calcium pantothenate, 0.4 gm.; choline chloride, 6.9 gm.; thiamine hydrochloride, 0.3 gm.; folic acid (not less than 3%), 8.6 gm.; pyridoxine hydrochloride, 0.1 gm.; vitamin E (20,000 mg./lb.), 20.0 gm.; vitamin $B_{12}$ (9 mg./lb.), 100 gm.; chlortetracycline (93%), 2.5 gm.; penicillin (800 mg./gm.), 0.6 gm.; streptomycin sulfate (467 mg./gm.), 2.4 gm.; soybean meal carrier, 740.3 gm.

*Experiment I*

Twenty-five baby pigs were allotted to five ration treatments. The experiment was terminated after 6 weeks. The pigs in lots 1, 2, 3, 4, and 5 received 0, 25, 50, 100, and 200 mg. of tolbutamide per lb. of ration, respectively. Blood glucose was determined for each pig at the time the experiment was started, at the end of the fourth week, and on the day the experiment was terminated.

*Results.* The results of this experiment are summarized in table 2. There

TABLE 2. SUMMARY OF AVERAGE PERFORMANCE DATA OF PIGS FOR EXPERIMENT I

| Tolbutamide per lb. ration, mg. | 0 | 25 | 50 | 100 | 200 |
|---|---|---|---|---|---|
| Lot. no. | 1 | 2 | 3 | 4 | 5 |
| No. of animals | 5 | 5 | 5 | 5 | 5 |
| Av. initial wt., lb. | 9.6 | 9.1 | 9.7 | 9.6 | 9.6 |
| Av. final wt., lb. | 47.6 | 50.8 | 48.5 | 50.1 | 48.5 |
| Av. daily gain, lb. | 0.91 | 0.99 | 0.92 | 0.97 | 0.93 |
| Av. daily feed consumed, lb. | 1.83 | 2.08 | 1.89 | 2.07 | 1.91 |
| Feed per lb. gain, lb. | 2.02 | 2.09 | 2.09 | 2.14 | 2.06 |
| Blood glucose, mg. per 100 ml. | | | | | |
| Initial[a] | 144 | 139 | 132 | 123 | 117 |
| Fourth week | 99 | 98 | 104 | 106 | 108 |
| Final | 93 | 97 | 97 | 96 | 93 |
| Change (initial to final)[b] | —51.2 | —42.7 | —35.1 | —26.7 | —24.0 |

[a] Significant difference ($P<0.01$).
[b] Treatment 1 significantly different from treatments 4 and 5 ($P<0.01$).

was no statistically significant treatment difference between average daily gains. Feed consumption and feed efficiency data were not suitable for statistical analysis. The treated pigs consumed slightly more feed than the control pigs; however, the control pigs made more efficient gains.

Initial and final blood glucose values revealed a significant lot difference initially, but not finally. The significant difference initially was not attributed to tolbutamide treatment, since the blood samples were drawn before the pigs were allowed to consume their rations. Analysis of the mean blood glucose change from initial to final revealed that the blood glucose concentration of the pigs treated with 100 and 200 mg. of tolbutamide per lb. of ration did not change as much as that of the control pigs. There was no significant difference in the mean blood glucose change between the control pigs and those treated with 25 and 50 mg. of tolbutamide.

Thus tolbutamide had no noticeable ability to produce hypoglycemia in the baby pig when administered at levels of 25, 50, 100, and 200 mg. per lb. of ration. Any effect that it may have had on feed consumption, feed efficiency, and rate of gain was negligible.

*Experiment II*

Two trials, A and B, were conducted. Trial A was concerned with the effect tolbutamide had on blood glucose concentration when mixed in the ration, while Trial B was concerned with the effect of tolbutamide administered by capsule.

Eight pigs were used in Trial A. Four pigs from four litters served as controls and received no tolbutamide, while a litter mate of each control pig received 12.5 mg. of tolbutamide per lb. of ration. The pigs were fasted for 3 hours, allowed to eat for ½ hour, and then the feeders were removed. Blood samples were drawn for glucose analysis 1½, 3, and 4½ hours after the feed was removed.

Pigs used in Trial A plus an additional litter mate from each of the four litters served as experimental animals for Trial B. One pig from each litter served as the control and received no tolbutamide. The other eight pigs received 100 mg. of tolbutamide by capsule after they were allowed to eat for ½ hour following a 3-hour fast. Blood samples were taken from each pig ½, 1½, 2½, and 3½ hours after the capsules were administered.

*Results.* In Trial A only a small difference in blood glucose concentration was found after 1½ hours between the control pigs and the pigs that received tolbutamide in their ration. At 3 hours post-feeding the treated pigs had substantially lower blood glucose concentrations than the control pigs, but after 4½ hours this difference had almost disappeared. The mg. of glucose per 100 ml. of blood at 1½, 3, and 4½ hours were respectively 115, 138, and 121 mg. for the control pigs and 111, 119, and 111 mg. respectively for the treated pigs.

In Trial B the respective blood glucose concentrations at ½, 1½, 2½, and 3½ hours after the tolbutamide capsules were administered were 119.3, 109.6, 101.0, and 119.5 mg. glucose per 100 ml. blood for the control pigs and 114.6, 105.9, 104.3, and 116.9 mg. for the treated pigs. Although the treated pigs had the lower concentration of blood glucose during most of the study, it is apparent that the blood glucose varied quite uniformly between the two groups and that the treated pigs were not hypoglycemic.

*Experiment III*

Since it appeared that tolbutamide did not effectively reduce the concentration of glucose in the blood when administered in the ration or by

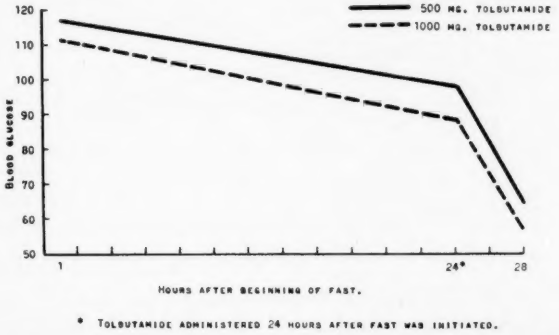


**Figure 1. Blood glucose curve for pigs treated with tolbutamide at end of 24-hr. fast (500 and 1000 mg. tolbutamide administered orally by a single capsule per pig). Experiment III, Trial A.**

capsule immediately after the pigs consumed a portion of their ration, it seemed pertinent to obtain information concerning the effects of tolbutamide when administered by capsule to fasted pigs. The following study was conducted in two phases, Trial A and Trial B. Six pigs were used for each trial.

In Trial A blood samples were drawn for glucose analysis 1 hour after the beginning of fast and again at 24 hours. Immediately after the 24-hour blood samples were taken, three pigs were given 500 mg. of tolbutamide by capsule and the other three were given 1000 mg. Four hours after the capsules were administered, blood samples were taken again.

In Trial B blood samples were drawn for glucose analysis after 1 hour of fast. Immediately, three pigs were given 500 mg. of tolbutamide and the other three 1000 mg. by capsule. Blood samples were drawn from all the pigs at intervals of 1, 4, and 8 hours after the tolbutamide was administered and at the end of the 24-hour fast period.

*Results.* The results of Trials A and B are shown in figures 1 and 2,

respectively. Tolbutamide demonstrated hypoglycemic activity in both of these trials. It appeared that when tolbutamide was administered at the beginning of the 24-hour fast (Trial B), that the 1000-mg. dose demonstrated more active hypoglycemic power than the 500-mg. dose. This difference was not as marked when the tolbutamide was administered at the end of the 24-hour fast (Trial A).

In Trial A the average blood glucose concentration was 116.8, 97.5, and 64.4 mg. glucose per 100 ml. of blood at 1, 24, and 28 hours, respectively, after the beginning of fast for the pigs that received 500 mg. of tolbutamide, and 110.8, 88.3, and 56.4 mg. for the pigs that received 1000 mg.

In Trial B the average blood glucose concentration was 115.2, 99.9,

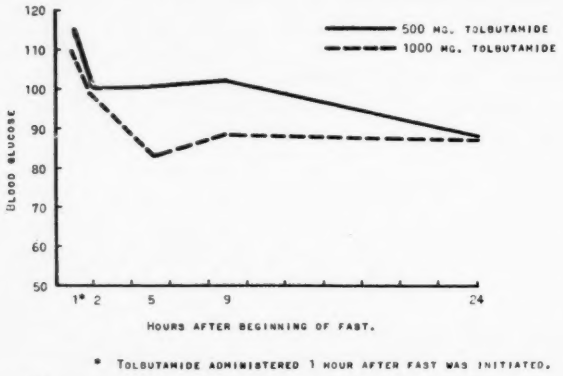


**Figure 2. Blood glucose curve for pigs treated with tolbutamide one hour after beginning of 24-hr. fast (500 and 1000 mg. tolbutamide administered orally by a single capsule per pig). Experiment III, Trial B.**

100.7, 101.9, and 88.0 mg. glucose per 100 ml. blood at 1, 2, 5, 9, and 24 hours, respectively, after the beginning of fast for the pigs that received 500 mg. of tolbutamide and 109.3, 97.9, 82.8, 88.6, and 87.3 mg. for the pigs that received 1000 mg.

*Experiment IV*

Since the data from Experiment I indicated that the lowest level of tolbutamide (25 mg./lb. feed) had a slight stimulatory effect on feed intake and rate of growth, this experiment was conducted to determine if levels below 25 mg. would be beneficial.

Five treatments were studied with 25 pigs in each of two replicates. The pigs in Treatments 1, 2, 3, 4, and 5 received 0, 2.5, 5.0, 7.5, and 10 mg. of tolbutamide, respectively, per lb. of ration. The experiment was terminated after 4 weeks and blood samples were drawn from the pigs in one

TABLE 3. SUMMARY OF AVERAGE PERFORMANCE DATA OF PIGS FOR EXPERIMENT IV

| Tolbutamide per lb. ration, mg. | 0 | 2.5 | 5.0 | 7.5 | 10.0 |
|---|---|---|---|---|---|
| Treatment no. | 1 | 2 | 3 | 4 | 5 |
| No. of animals | 10 | 10 | 10 | 10 | 10 |
| Av. initial wt., lb. | 8.2 | 8.3 | 8.2 | 8.2 | 8.2 |
| Av. final wt., lb. | 23.2 | 22.7 | 24.3 | 25.3 | 25.0 |
| Av. daily gain, lb. | .54 | .52 | .58 | .61 | .60 |
| Av. daily feed consumed, lb. | 1.34 | 1.15 | 1.12 | 1.21 | 1.19 |
| Feed per lb. gain, lb. | 2.49 | 2.22 | 1.94 | 1.98 | 1.98 |
| Blood glucose at termination of experiment, mg. per 100 ml. | 108.00 | 111.00 | 106.00 | 110.00 | 115.00 |
| Liver glycogen, % | 1.83 | 2.45 | 2.21 | 1.56 | 2.41 |

of the two replicates and analyzed for glucose concentration. Liver samples, taken by biopsy from two pigs in each treatment of the same replicate from which the blood samples were taken, were analyzed for glycogen content.

*Results.* The results are presented in table 3. Statistical analysis of gains, feed consumption and liver glycogen content did not show a significant treatment effect. Blood glucose and feed efficiency data were not analyzed, but treatment effects were not apparent.

*Experiment V*

This experiment was similar to Experiment IV, except that Treatments 1, 2, 3, 4, and 5 were 0, 15, 20, 25, and 800 mg. of tolbutamide per lb. of ration, respectively. The 800 mg. level was included because a preliminary experiment had indicated that levels of 800 and 1000 mg./lb. caused a reduction in growth rate.

*Results.* As shown in table 4 the pigs which received 800 mg. of tolbuta-

TABLE 4. SUMMARY OF AVERAGE PERFORMANCE DATA OF PIGS FOR EXPERIMENT V

| Tolbutamide per lb. ration, mg. | 0 | 15 | 20 | 25 | 800 |
|---|---|---|---|---|---|
| Treatment no. | 1 | 2 | 3 | 4 | 5 |
| No. of animals | 10 | 10 | 10 | 10 | 10 |
| Av. initial wt., lb. | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 |
| Av. final wt., lb. | 26.8 | 25.6 | 25.8 | 23.9 | 22.3 |
| Av. daily gain, lb. | .65** | .60* | .61* | .54 | .49 |
| Av. daily feed consumed, lb. | 1.49 | 1.41 | 1.37 | 1.43 | 1.10 |
| Feed per lb. gain, lb. | 2.30 | 2.33 | 2.24 | 2.63 | 2.26 |
| Blood glucose at termination of experiment, mg. per 100 ml. | 111 | 103 | 98 | 108 | 104 |
| Liver glycogen, % | 2.07 | 1.85 | 2.07 | 1.96 | 2.50 |

** Significantly higher than treatment 5 ($P<0.01$).
* Significantly higher than treatment 5 ($P<0.05$).

mide made significantly ($P<.01$) lower gains than the control pigs. There was no significant difference in gains between the pigs of the other treatments and the control pigs. Although the pigs that received 800 mg. of tolbutamide per pound of ration consumed less feed daily throughout the experiment than those of the other treatments, statistical analysis of the data failed to show a significant difference in feed consumption among the various treatments. There were no significant treatment differences in blood glucose concentration or liver glycogen content; however, at the end of the experiment the pigs treated with the 800-mg. level had a slightly greater percentage of glycogen in the liver than the pigs of other treatments.

*Experiment VI*

In the previous experiments tolbutamide failed to lower the blood glucose concentration when administered to the nonfasted pig. Therefore, insulin was used in this experiment to determine the insulin dosage that would substantially lower the blood glucose without causing insulin shock. Four baby pigs were individually weighed and the insulin doses were adjusted to the body weight. Blood samples were taken immediately before the insulin injection, and periodically at 1, 7, and 24 hours after the injection. The pigs were allowed to eat during this study. Two pigs were injected intramuscularly with 2 units of insulin per kg. body weight and two with 1 unit.

*Results.* Both levels of insulin were effective in lowering the blood glucose concentration with the largest reduction from the 2-unit dosage. At the end of one hour the 1-unit dose had reduced the blood glucose from 115 to 70 mg., while the 2-unit dose reduced it from 105 to 59 mg. The glucose concentration at the seventh hour had increased to 110 and 104 for the 1- and 2-unit doses, respectively. Glucose determinations made 24 hours after insulin injection showed that the pigs which had received 1 and 2 units had concentrations of 141 and 125 mg., respectively. The pigs that received 2 units of insulin per kg. of body weight showed symptoms of insulin shock. The fluctuation in blood glucose also indicated that additional information concerning the duration of the hypoglycemic state was needed.

*Experiment VII*

To study more closely the blood glucose curve after injection of insulin, four baby pigs were injected intramuscularly with 1 unit of insulin per kg. of body weight. Blood samples were drawn for glucose analysis before injection and at intervals of 1, 3, 7, and 12 hours after injection.

*Results.* The data in figure 3 show that there was a reduction of glucose for the first 3 hours following insulin injection. This was followed by a period of hyperglycemia (7th hour) and then a return to normal at 12 hours.

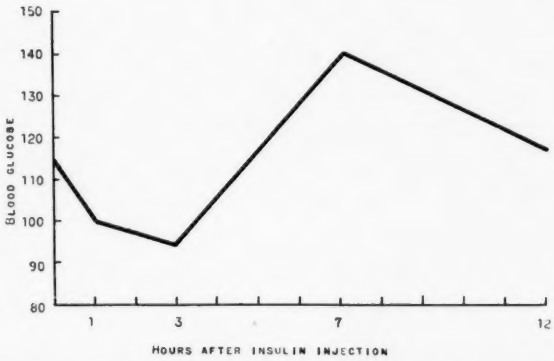


**Figure 3. Blood glucose curve for pigs 1, 3, 7, and 12 hours after injection of 1 unit of insulin per kilogram body weight. Experiment VII.**

*Experiment VIII*

The effect of insulin hypoglycemia on feed consumption was determined with 15 pigs allotted to three treatments, 0.0, 0.5 and 1.0 unit of insulin, respectively, per kg. body weight every 12 hours. The pigs in Treatment 1 served as the controls. Blood samples were taken from each pig at the end of the second week of the experiment. The blood samples were taken approximately 3 hours after the routine morning injections.

*Results.* The pigs that were injected with 1.0 unit of insulin made significantly ($P<.05$) lower gains than the control pigs; and, those injected with 0.5 and 1.0 unit had significantly ($P<.05$) lower blood glucose concentrations. Also, the pigs injected with 1.0 unit of insulin required considerably more feed per lb. of gain than the other pigs. These data are summarized in table 5.

TABLE 5. SUMMARY OF AVERAGE PERFORMANCE DATA OF PIGS FOR EXPERIMENT VIII

| Insulin units/kg. body wt. | 0 | 0.5 | 1.0 |
|---|---|---|---|
| Treatment no. | 1 | 2 | 3 |
| No. of animals | 5 | 5 | 5 |
| Av. initial wt., lb. | 9.0 | 9.0 | 9.0 |
| Av. final wt., lb. | 20.2 | 19.3 | 17.9 |
| Av. daily gain, lb. | .54 | .49 | .33* |
| Av. daily feed consumed, lb. | .78 | .70 | .65 |
| Feed per lb. gain, lb. | 1.45 | 1.44 | 1.87 |
| Blood glucose at termination of experiment, mg. per 100 ml. | 95 | 48** | 64* |

** Significantly lower than treatment 1 ($P<0.01$).
* Significantly lower than treatment 1 ($P<0.05$).

*Discussion*

Recant and Fischer (1957) found that tolbutamide had hypoglycemic activity in their studies with human beings and rats; Frawley *et al.* (1957) found that tolbutamide had hypoglycemic activity when administered to the dog; however, similar studies with swine were not revealed by a comprehensive search of the literature.

In the study reported herein, tolbutamide did not demonstrate hypoglycemic activity when administered to nonfasted pigs. The levels fed ranged from 2.5 mg. to 1000 mg. of tolbutamide per pound of ration. In Experiment V a ration containing 800 mg. of tolbutamide per pound was fed, which was one of the highest levels administered to nonfasted pigs. Calculations involving body weight and feed consumed show that during the last week of this experiment each pig in the 800-mg. lot consumed approximately 0.14 gm. of tolbutamide per kg. of body weight, yet the blood glucose concentrations were not significantly lower than those of the control pigs. Recant and Fischer (1957) injected rats intraperitoneally with 0.40 gm. of tolbutamide per kg. body weight and the blood glucose concentrations were reduced by 28% in 30 minutes. This suggests that the amount of tolbutamide consumed per unit of body weight by the baby pigs at any given time may have been too small to produce hypoglycemia. However, this postulation would be difficult to confirm since feed consumption and consequently rate of gain were already adversely influenced by the presence of 800 mg. of tolbutamide per pound of ration. The methods used to administer tolbutamide may also partially account for the differences obtained between this study and that of Recant and Fischer (1957).

In Experiment III when the pigs were fasted and then administered 500 or 1000 mg. of tolbutamide by capsule hypoglycemia was produced. This suggests that either tolbutamide was not capable of producing hypoglycemia when ingested simultaneously with the ration and/or that the levels used were too small. If the tolbutamide and the simple sugars from carbohydrate digestion are absorbed into the blood simultaneously the hypoglycemic properties of tolbutamide may be masked.

Although insulin was effective in producing hypoglycemia, it had an adverse effect on growth rate. The levels used may have been excessive since one of the insulin treated pigs in Experiment VII exhibited symptoms associated with insulin shock. The performance of other pigs in this experiment may have also been slightly affected by an excessive amount of insulin although no gross symptoms were observed.

## Summary

A series of eight experiments involving 162 early weaned baby pigs was conducted in an attempt to determine if feed consumption could be stimulated by experimental hypoglycemia.

Tolbutamide failed to produce hypoglycemia; therefore, no conclusive results were obtained regarding the relationship between blood glucose concentration and feed consumption. Tolbutamide demonstrated active hypoglycemic properties when administered orally by capsule to fasted pigs (500 or 1000 mg./pig). When mixed in the ration at the rate of 800 mg. per lb. it reduced rate of growth significantly. It did not appear to be toxic at the levels studied.

Insulin injected in one experiment at the rate of 0.5 and 1.0 unit per kg. body weight every 12 hours produced hypoglycemia and also reduced feed consumption and rate of gain.

Feed consumption and average daily gains were not stimulated by any of the treatments studied.

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# A RAPID METHOD FOR THE DETERMINATION OF ACID-INSOLUBLE LIGNIN IN FORAGES AND ITS RELATION TO DIGESTIBILITY [1]

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CURRENT methods for the determination of lignin are lengthy, a fact which discourages the use of lignin as an indicator of quality in forages. In search of a simpler and more rapid method, a study was made of the acid-insoluble lignin method of Moon and Abou-Raya (1952a). In many methods 72% $H_2SO_4$ is used for the solubilization and hydrolysis of the cellulose. This strong acid is then diluted whereupon a substance, soluble in the strong acid, is precipitated. Moon and Abou-Raya, following Paloheimo (1929), filtered the strong acid without dilution and thereby discarded this substance thought by some to be an artifact arising during the analysis but later reported by Moon and Abou-Raya (1952b) to be ligneous and rightfully included in total lignin. However, limiting the product to lignin insoluble in 72% $H_2SO_4$ and eliminating and shortening other steps resulted in a more rapid method, and the amount of the product is satisfactorily correlated with digestibility of forage.

## Procedure

Weigh 1–2 gm. dried forage ground to pass through a 40-mesh screen into a tall 200 ml. beaker. Add 30–40 ml. benzene-alcohol (2.5:1.0) and either boil gently on a steam bath for several hours or allow to stand overnight and then boil for a short time. Pour into a Gooch-type crucible (low form) with fritted Pyrex disk, size 30C and containing an asbestos mat, and allow to filter slowly with light suction. Rinse the residue, which need not be transferred quantitatively to the crucible, two or three times with benzene-alcohol, three times with acetone, and three times with water. Transfer as much of the solid material as possible, including the asbestos, back to the beaker and add pepsin solution (1 gm. pepsin in 100 ml. 0.1 N HCl). Most of the material can be removed by lifting the mat with a rod and the remainder by rinsing the crucible with pepsin solution from a wash bottle. Use about 40 ml. pepsin solution in all. Place in a

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cabinet at 45° C. for 20–24 hours, and mix occasionally during the first few hours. Then pour through the same crucible, transfer the solid matter quantitatively to the crucible, and wash several times with water. Pour about 25 ml. concentrated HCl, previously cooled to about 15°, through the crucible, adjusting the rate of flow by manipulating the suction so that the time of contact with the sample is about 2 minutes. Wash with water, and then with alcohol and ether and allow to air-dry. Add sufficient 72% $H_2SO_4$, previously cooled to about 15° C. to cover the contents of the crucible. Stir with a 3-inch flattened glass rod which is allowed to remain for the time in the crucible. Be sure all particles come in contact with the acid and break up any lumps. Place the crucible in a 50-ml. beaker for support and for receiving the acid which percolates through slowly and is to be discarded, and maintain the temperature as closely to 20° C. as convenient. Stir occasionally and add fresh acid as necessary to keep the mixture fluid. At the end of about 3 hours return the crucible to the suction flask and remove the acid, without dilution, by filtration. Wash the residue thoroughly with hot water to remove all traces of acid. Dry overnight at 105–110° C. and determine the acid-insoluble lignin by the loss in weight on ignition at 500° C.

It is important that the forage sample be ground to 40-mesh or finer and conditions for rapid filtration be maintained. The crucible should be of coarse porosity and the asbestos fairly free of fine particles. After use, the asbestos is removed and the crucible cleaned by inverting it and drawing water through under suction. As crucibles become clogged with repeated use, probably by asbestos, they may be cleaned by boiling with 5% sodium hydroxide for 5 minutes and then washing while inverted. Slow crucibles should not be used; a crucible which requires more than 80 seconds for the percolation of 25 ml. water at room temperature without suction is too slow. The crucibles should not be heated above 500° C. The 72% $H_2SO_4$ may be prepared by mixing 175 ml. concentrated acid into 100 ml. water, cooling, and adjusting to sp. gr. 1.634 at 20° C.

*Discussion of the Method.* The above procedure differs from many published methods, for example that of Ellis, Matrone, and Maynard (1946), in having fewer and less time-consuming steps. It is estimated that in a given time twice as many samples can be analyzed for acid-insoluble lignin as for total lignin. In the extraction with fat solvent, the use of a Soxhlet or other extraction apparatus is eliminated. Overnight digestion with pepsin at 45° C. is sufficient if a wet contact is made between the sample and the pepsin solution; otherwise, a longer period of digestion is required to give a comparable yield of lignin. Two boilings commonly carried out with dilute $H_2SO_4$, one before and one after the main treatment with the 72% acid, are both eliminated. In place of the first one is a brief washing with cold concentrated HCl for a shorter time than that used by Moon and Abou-Raya (1952a). This washing is not essential to the results with grass,

but it removes a large part of the nonligneous material and facilitates the later filtration of the strong sulfuric acid. In alfalfa the washing with hydrochloric acid does remove material which contributes to the final weight of lignin. In the treatment with 72% $H_2SO_4$ the exact time is not important to the results, but 2 hours is needed for the residue to reach a constant weight in most samples and 3 hours in others. The second boiling with dilute acid, after the treatment with the strong acid, is eliminated. This last boiling may result in a lower yield of lignin but whether lignin is attacked or nonligneous material is removed by it has not been determined. This last boiling has been one cause of variable results in other methods.

Methods such as those of Ellis, Matrone, and Maynard (1946), Norman and Jenkins (1934), and Crampton and Maynard (1938), are attempts to determine total lignin. The investigations of such writers as Paloheimo (1929) and Moon and Abou-Raya (1952a, b) have shown that lignin is a mixture with various degrees of condensation and that upon acid treatment some is lost by hydrolysis but at the same time apparent lignin-like substances, such as condensation products of carbohydrates, nitrogenous and other absorbed substances, are included. Avoiding high temperatures with acids and filtering the 72% acid without dilution partly but not entirely prevent the inclusion of condensed and absorbed substances. The slow percolation of the strong acid through the crucible during the 3-hour period and its replacement with fresh acid aid in removing dissolved substances which would be precipitated on long contact.

There is no absolute method for determining lignin in forages. Methods for acid-insoluble lignin, and for lignin which for convenience we call total lignin, are empirical in that the amount and purity of the product depend on the conditions of isolation. A method has a great advantage if, while still empirical, moderate variations in the conditions will not seriously affect the results. This is believed to be the case here. The acid-insoluble lignins are not pure. They are light to dark gray in color and contain 1.9–3.6% nitrogen which is not removed by treating the lignin with pepsin. The percentages of acid-insoluble lignin obtained by the method are in general lower than those obtained by the method of Ellis, Matrone, and Maynard (1946); exceptions occur with very immature grasses and legumes in which the acid-insoluble lignin was not lower than the "total" lignin and in a few cases was higher. For the purposes of this study it is essential only that the result furnish an index of the feeding value of the forage.

*Relation of Acid-Insoluble Lignin to Digestible Dry Matter.* Forage samples of known digestibility were obtained from state experiment stations. Except for the silages, the forages apparently came from pure stands and had been artificially dried. Digestibility has been determined with sheep or cattle, the number of animals varying from one to six, but in most cases being four. The digestion coefficient accepted for each was the average obtained from the animals.

The forages were analyzed for acid-insoluble lignin and correlation and regression values between the percentages of lignin and the digestion coefficients of dry matter were calculated. The results are affected to a variable extent by the species and manner of preservation of the forages. The number of animals used in the digestion trials is one factor in the general reliability of the digestion data. The type of animal was not a basis of segregation.

The relationships of the acid-insoluble lignin to digestibility are summarized in table 1. Groupings were made according to species of plant, not station of origin. An exception is made with bromegrass. In line 1 of the table 13 samples of bromegrass from two stations gave satisfactory correlation and regression values when grouped together. From a third station

TABLE 1. RELATIONSHIPS BETWEEN PERCENTAGES OF ACID-INSOLUBLE LIGNIN AND DIGESTIBILITY DATA OF FORAGES OBTAINED FROM AGRICULTURAL EXPERIMENT STATIONS

| | Species | No. of samples | No. of animals[a] | Range of DDM. | Range of % lignin | Coef. of corr., r | Regression values | Stand. dev. |
|---|---|---|---|---|---|---|---|---|
| 1 | Bromegrass | 13 | 2–4 Sh | 57–78 | 4.4–7.5 | —.99 | 97.8— 5.57X | 0.9 |
| 2 | Bromegrass | 12 | 1 Sh | 57–67 | 5.4–7.1 | —.53 | 78.7— 2.97X | 2.9 |
| 3 | All bromegrass | 25 | ..... | 57–78 | 4.4–7.5 | —.86 | 96.3— 5.67X | 3.1 |
| 4 | Orchardgrass | 18 | 2–4 Sh or 3 B | 55–69 | 3.8–6.7 | —.89 | 103.8— 6.62X | 2.7 |
| 5 | Timothy | 9 | 2–4 Sh or 3 St | 50–67 | 5.4–7.7 | —.92 | 98.4— 5.91X | 1.8 |
| 6 | Ky. bluegrass | 4 | 2–4 Sh | 69–77 | 3.4–5.1 | —.99 | 93.4— 4.68X | 0.6 |
| 7 | Sudangrass | 4 | 3 C or 3 B | 66–73 | 5.3–5.7 | —.94 | 151.5—15.45X | 0.9 |
| 8 | Reed canarygrass | 12 | 1 Sh | 57–69 | 2.7–5.7 | —.68 | 73.3— 2.11X | 2.3 |
| 9 | Sum 3–7 incl. | 60 | ..... | 50–78 | 3.4–7.7 | —.90 | 99.8— 6.11X | 2.8 |
| 10 | Sum 1, 4–7 incl. | 48 | ..... | 50–78 | 3.4–7.7 | —.95 | 100.8— 6.15X | 2.1 |
| 11 | Alfalfa | 27 | 1–6 Sh or 1–6 St or 3 B | 53–71 | 7.5–12.8 | —.75 | 81.6— 2.10X | 2.7 |
| 12 | Alfalfa silage | 5 | 2–5 Sh | 56–65 | 7.8–12.7 | —.98 | 79.3— 1.83X | 0.6 |
| 13 | Red clover silage | 12 | 2–6 Sh | 51–68 | 11.0–18.3 | —.90 | 85.7— 1.87X | 1.8 |

[a] Sh=sheep; St=steers; B=bull calves; C=cows.

were received 12 samples of bromegrass which gave more variable results, probably because each had been fed to only one animal apiece; these appear separately on line 2. If all 25 samples of bromegrass are grouped together, as on line 3 of the table, the regression equation is changed only slightly from that of line 1 but the deviation is increased. Orchardgrass, timothy, and Kentucky bluegrass (lines 4, 5, and 6) have regression lines not too distant from those of bromegrass. That of Sudangrass (line 7) is different but the four samples fall close to the regression lines of the other grasses. This is also the case with the four samples of Kentucky bluegrass, and the agreement in each case may be fortuitous. Reed canarygrass (line 8) alone appears to differ markedly from other species of grass. The samples of reed canarygrass, like those of bromegrass in line 2, were fed to only one animal each. Two general equations are given in lines 9 and 10. In line 9 all samples of bromegrass, orchardgrass, timothy, Kentucky blue-

grass, and Sudangrass are combined; of the grasses only reed canarygrass is excluded. In line 10 the bromegrass in line 2 as well as the reed canarygrass is excluded. There is no material difference between the calculated data in lines 9 and 10 except that the standard deviation is greater in line 9. The data in line 9 are illustrated in figure 1.

Dried alfalfa, alfalfa silage, and red clover silage in which there was some admixture of alfalfa, all give separate regression data.

For 36 samples on which energy data are available, the coefficient of

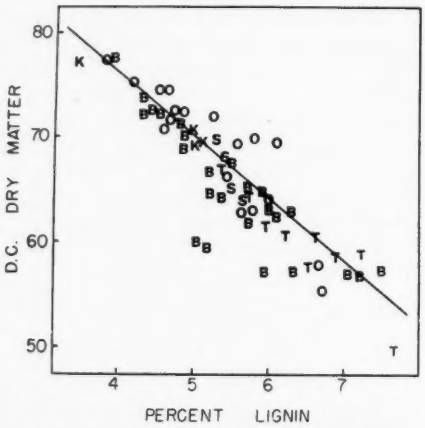


**Figure 1. Relation between percentage of acid-insoluble lignin and the digestion coefficient of dry matter in five species of forage grasses, bromegrass (B), orchardgrass (O), timothy (T), Kentucky bluegrass (K), and Sudangrass (S). The regression line is a general one, Y=100—6 X.**

correlation (r) between the coefficient of digestible energy (D.E.) and the percentage of acid-insoluble lignin (X), and the regression values are:

r=—0.94; D.E.=98.0—6.21 X; and the standard deviation (S.D.)=2.3.

In order to determine whether the acid-insoluble lignin is digestible, the feces from 36 animals fed different samples of grass were analyzed. The average digestion coefficient was —2.4, but the standard error of ±8.9 indicates that acid-insoluble lignin is not a satisfactory reference substance. Only 0.5-gram sample of feces was used in a determination in order to obtain easy filtration.

The reliability of the acid-insoluble lignin in predicting the digestibility of the dry matter (DDM.) is essentially the same as that of total lignin.

For 35 samples, all grass and of 4 species and from the same station, the method of Ellis, Matrone, and Maynard (1946) gave the following:

$$r=-0.95;\ DDM.=95.64-4.02\ Z,$$ where Z is total lignin; S.D.=2.0.

The method for acid-insoluble lignin (X) gave with the same 35 samples:

$$r=-0.94;\ DDM.=100.37-6.08\ X;\ S.D.=2.1.$$

*Discussion*

While each species of grass gives a separate regression equation (table 1), a number of species may be combined in a general equation. A simplified and tentative equation is proposed: $DDM.=100-6\ X$, which may be applied to many, if not all, species of grass, as illustrated in figure 1. Of the 60 samples illustrated in figure 1, prediction of the digestion coefficient in 39 (65%) is made within $\pm 2$. In 12 samples prediction is outside $\pm 3$, but 7 of these 12 are bromegrass from line 2 of the table which were not replicated in the digestion trials. The only samples absent from the figure are reed canarygrass which also were not replicated. The reed canarygrass would appear well below the line in the left portion of the figure, the lignin content being much lower than would be expected from the digestion coefficients. The equation, $DDM.=100-6\ X$, might therefore be considered a general relationship existing in some species of grass between digestibility and lignin determined as described. Further study on more samples of forage, of a wider range of quality, and in some cases with more accurate digestion data, may verify and broaden the value of the test. As the majority of the grasses studied were first cuts, more data are needed on later cuts, on summer and fall cuts. The method is intended for routine testing and screening numbers of samples of forages grown in small plots or as spaced plants in quantities too small for feeding trials.

The problem of predicting the digestion coefficients of mixtures has not been solved. The only feasible method at present seems to be the manual separation of grass and legumes at harvest and the analysis of each lot. This assumes that the digestibility of each is additive.

## Summary

A method described for the determination of acid-insoluble lignin modifies that of Moon and Abou-Raya and adapts it to rapid, routine testing of forages. Relation of the percentage of acid-insoluble lignin to the digestibility of dry matter has been demonstrated. In certain species of grass the digestion coefficient of dry matter is approximately equal to 100 minus 6 times the percentage of acid-insoluble lignin. It is proposed that the method be used in evaluating and screening forages grown in quantities too small for feeding trials.

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# INFLUENCE OF LEVEL OF INTAKE UPON THE APPARENT DIGESTIBILITY OF FORAGES AND MIXED DIETS BY RUMINANTS

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IT is generally believed unqualifiedly that the digestibility of a given ration decreases as the level of intake increases. In a study (Reid, 1956) of published data dealing with the relationship of feed input to milk output by dairy cows, it appeared that the digestibility of mixed rations (concentrates and forages) by cows declines as the level of intake increases, but that the digestibility of all-forage rations is unaffected.

Although in some of the experiments dealing with this problem the range of intake imposed was small, the bases of the contention that increasing levels of intake of long or chopped, all-forage diets above the maintenance level do not depress digestibility by herbivorous animals are the data obtained with cattle fed hays (Henneberg and Stohmann, 1860, 1864; Armsby and Fries, 1905, 1908, 1911; Watson *et al.*, 1935; Hale *et al.*, 1940), with horses fed hays (Wolff, 1877; Muntz and Girard, 1898), and with sheep fed hays (Wolff, 1872, 1877; Tangl and Weiser, 1911a, b; Honcamp and Koch, 1920; Blaxter and Graham, 1954; Blaxter *et al.*, 1956) and grass silage (Tangl and Weiser, 1911a, b). On the other hand, the digestibility by sheep of a finely ground and pelleted forage decreased markedly as the level of intake increased (Blaxter and Graham, 1956).

The results of more detailed experiments demonstrate that the digestibility of rations composed of both concentrates and forages is depressed as the level of intake by the following animals increases: Cattle (Eckles, 1911; Kellner, 1912; Mumford *et al.*, 1914; Trowbridge *et al.*, 1915; Forbes *et al.*, 1928, 1930; Mitchell *et al.*, 1932), sheep (Jordan and Jenter, 1897), horses (Edin and Eriksson, 1929), and rabbits (Hellberg, 1949). Increasing intakes by cattle of mangels (Eskedal, 1934) and of corn silage (Watson *et al.*, 1939) also resulted in increasingly lower digestibility. In general, these data indicate that the effect of the level of intake is more pronounced for high-concentrate rations than for low-concentrate rations.

The plane-of-nutrition effect has not been demonstrated in all experiments in which mixed diets were fed. Using dry cows fed 70,100 and 130% of standard allowances, Lassiter *et al.* observed an improvement in digestibility as the level of intake increased in one experiment (1957), but no effect in another (1958). It seems possible that when a narrow range of intake encompassing sub- and super-maintenance levels are studied, the

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usual effect of plane of nutrition observed above the maintenance level may not be obtained. With some rations a parabolic response has been observed in which the digestibility of the sub-maintenance ration is lower than that of the same ration fed at the maintenance level.

It is interesting to note that the level of intake had no effect upon digestibility by the pig (Mitchell and Hamilton, 1929).

The apparent contribution of the plane-of-nutrition effect to diminishing returns in livestock production is sufficiently great to warrant further study. With the exception of Experiment 5, the studies to be reported here were not designed specifically to study the effect of level of intake. Although these experiments had other objectives, the data obtained contribute to the knowledge concerning the effect of the level of intake particularly of feeds not studied in this respect previously and of feeds different in quality from those which have been studied.

## Experimental Procedure

The effect upon digestibility of the amount of feed consumed was studied in five experiments constituted by a series of 33 conventional digestion trials conducted with steers or wethers. In those experiments (1, 2 and 5) which were so adapted, the data were subjected to an analysis of variance; in the other experiments (3 and 4) the data were studied by correlation and regression analysis.

*Experiment 1.* Fresh, green, first-growth alfalfa-Ladino clover-bromegrass forage was fed at the rates of 700, 1000 and 1200 gm. of dry matter per day in two meals. Two 2-year-old wethers weighing approximately 90 lb. were allotted to each level on which they remained throughout the experiment. After a 2-week preliminary feeding period the first trial was begun on April 29. During each of the 7 succeeding weeks a digestion trial of 7-day duration was conducted.

*Experiment 2.* Fresh, green aftermath forages consisting of the second, third and fourth growths harvested from the same source as the forage used in Experiment 1 were fed to the same wethers at the same levels employed in Experiment 1. Each of the 13 trials constituting this experiment was conducted during consecutive 1-week periods.

*Experiment 3.* Two digestion trials of 8-day duration were conducted during a feeding trial in which eight Holstein steers, 16 to 21 months old at the beginning of the experiment, were fed a first-cutting, mixed legume-grass hay (harvested on June 23) at eight levels ranging from 0.9 to 1.7 times the amount of dry matter required for maintenance. A constant intake of feed was provided during the 31-day period immediately prior to the first digestion-trial period (trial no. 21) and during the 180-day period preceding the second trial (trial no. 22). The level of dry matter intake required to maintain body weight $^{0.73}$ was determined by regres-

sion; other levels of intake were then expressed (table 1) as multiples of the maintenance level with body weight raised to the power, 0.73, as a parameter to relate the intakes of steers of different body weights.

*Experiment 4.* This experiment consisted of three trials in which mixed rations (containing both concentrates and forages) were fed. The concentrate mixture consisted of 9.9% soybean meal, 89.1% ground corn and 1.0% salt. In trials 23 and 24, rations comprised of 80% of the concentrate mixture and 20% mixed legume-grass hay were fed at 5 and 8 levels, respectively, ranging from 1.1 to 2.1 and 0.6 to 3.1 times the maintenance level to Holstein steers 18 to 36 months old. A ration containing 60% of the concentrate mixture and 40% mixed hay was fed at five levels ranging from 1.1 to 1.9 times the maintenance level to five 3-year-old steers in trial 25. The level of intake assumed to be equivalent to the maintenance intake was computed according to Brody's equation (1945): Digestible energy (Kcal.)$=2 \times 39.5$ body weight$^{0.73}$ (in lb.)

*Experiment 5.* The eight rations fed in this experiment were composed of 0, 25, 50, and 75% of the same concentrate mixture and 100, 75, 50 and 25%, respectively, of each of two hays. Ten Angus X Holstein steers and six Holstein steers ranging in age from 8 to 12 months at the beginning to 13 to 17 months at the end of the experiment were employed in conventional digestion trials. The observations made on a given ration combination were distributed throughout the 5-month period. An attempt was made to expose as many individual steers as possible to a given treatment; this was limited by the quantity of hay available. Preliminary feeding periods of 18 to 24 days (depending upon the severity of the change from the previous ration to the new ration) preceded fecal-collection periods of 8, 9 or 10 days.

The concentrate mixture used in this experiment had the following percentage composition: Ground corn, 73.5; ground oats, 9.8; wheat bran, 9.8; soybean meal, 4.9; iodized salt, 1.0 and dicalcium phosphate, 1.0. The hays were a first-growth, heat-dried, alfalfa-Ladino clover-bromegrass mixture harvested at different times; the early-cut sample (fed in trials 26–29) was cut on May 29 and the late-cut sample (fed in trials 30–33) was cut on July 9.

Each of the four diets containing the early-cut hay was fed at 8 to 13 different levels ranging from 1.0 to 2.5 times the maintenance level. Each of the four rations containing the late-cut hay was fed at four or five different levels ranging from 1.0 to 1.9 times the level required for maintenance. Levels of the late-cut hay diets higher than 1.9 times the maintenance level were refused. The maintenance requirement of the steers for digestible energy (DE) was computed according to the following equation proposed by Brody (1945): DE (Cal./day)$=2 \times 39.5$ body weight$^{0.73}$ (in lb.). From the digestible energy value of each ration determined at approximately maintenance, the amount of dry matter equivalent to the

maintenance level was derived. This served as the reference for computing the plane of nutrition of the individual animals.

## Results and Discussion

Some of the pertinent data (trial number, range in level of intake, mean digestibility and inter-animal coefficient of variation) obtained in the five experiments are summarized in table 1. In a study of 110 previous digestion trials conducted in this laboratory involving all-forage and mixed diets fed to groups of 3 to 12 cattle or 2 to 6 sheep at levels approximating maximum intakes without feed refusals, the mean inter-animal coefficient of variation in the digestibility of dry matter was found to be of the order of 2.2%. This figure representing the variation associated with the animal serves as a reference value with which to help evaluate the responses to different levels of feed in the present experiments. Thus, unless the coefficient of variation recorded in table 1 is considerably greater than 2.2%, it is unlikely that the treatments imposed contributed to the variation.

Although the digestibility of the forage harvested during the seven periods of Experiment 1 was significantly different ($P<0.01$), the level of intake was without effect ($0.2<P<0.3$) upon digestibility. In Experiment 2, the digestibility of the forages was significantly different ($P<0.01$) for the 13 periods and, although level of intake approached a mathematically significant effect ($0.05<P<0.1$), the difference in digestibility effected by the level of intake was of no biological consequence. The digestibility of the dry matter by the wethers consuming the highest level (1200 gm./day) was lower than that of the wethers consuming the lowest level (700 gm./day) by only the following percentage units in the various trials: 8, 0.6; 9, 1.1; 10, 2.7; 11, 2.3; 12, 1.7; 13, 2.2; 14, 1.6; 15, 2.9; 16, 1.5; 17, 2.5; 18, 0.4; 19, 1.0 and 20, 0.4. On the average the forage consumed at the lowest level was only 2.4% more digestible than that consumed at the highest level. Furthermore, the forage consumed at the high level was less digestible than that consumed at the medium level (1000 gm./day) in only three of the 13 trials. Thus, it is concluded that the amount of forage consumed had no effect of biological significance upon digestibility.

Since the wethers used in Experiments 1 and 2 remained on the same treatments throughout, animals and treatments are confounded. This manner of conducting Experiments 1 and 2 resulting in a gain of weight by the high-level wethers also diminished the relative difference between the planes of nutrition with respect to body weight as the experiments progressed.

Although the digestibility of the hay fed in Trial 21 (Experiment 3) was significantly correlated ($r=-.7$) with the level of intake, the TDN value (58.3%) at the lowest level of intake was only 0.9 percentage units higher than the TDN value (57.4%) at the highest level of intake. No

TABLE 1. SUMMARY OF LEVELS OF INTAKE IMPOSED AND THE COMPOSITION AND APPARENT DIGESTIBILITY OF RATIONS

| Trial no. | No. of observations | Forage in ration | Range of intakes | Mean digestibility[c] | Coeff. of variation |
|---|---|---|---|---|---|
| | | % | | % | |
| Experiment 1: Green, first-growth forage | | | | | |
| 1 | 6 | 100 | L, M, H[a] | 82.7 | 1.05 |
| 2 | 6 | 100 | L, M, H | 80.8 | 1.73 |
| 3 | 6 | 100 | L, M, H | 79.4 | 0.74 |
| 4 | 6 | 100 | L, M, H | 78.4 | 2.17 |
| 5 | 6 | 100 | L, M, H | 74.0 | 3.47 |
| 6 | 6 | 100 | L, M, H | 70.1 | 3.09 |
| 7 | 6 | 100 | L, M, H | 64.7 | 3.42 |
| Experiment 2: Green, aftermath forage | | | | | |
| 8 | 6 | 100 | L, M, H | 67.8 | 1.53 |
| 9 | 6 | 100 | L, M, H | 64.9 | 1.81 |
| 10 | 6 | 100 | L, M, H | 65.9 | 3.35 |
| 11 | 6 | 100 | L, M, H | 67.5 | 2.08 |
| 12 | 6 | 100 | L, M, H | 64.9 | 1.55 |
| 13 | 6 | 100 | L, M, H | 62.4 | 3.03 |
| 14 | 6 | 100 | L, M, H | 65.9 | 2.69 |
| 15 | 6 | 100 | L, M, H | 67.8 | 2.23 |
| 16 | 6 | 100 | L, M, H | 64.3 | 2.23 |
| 17 | 6 | 100 | L, M, H | 70.2 | 2.33 |
| 18 | 6 | 100 | L, M, H | 66.9 | 2.39 |
| 19 | 6 | 100 | L, M, H | 69.7 | 0.70 |
| 20 | 6 | 100 | L, M, H | 72.3 | 1.65 |
| Experiment 3: Hays | | | | | |
| 21 | 8 | 100 | 0.91–1.65[b] | 58.0 | 0.80 |
| 22 | 8 | 100 | 0.95–1.51 | 60.6 | 1.46 |
| Experiment 4: Mixed concentrate—hay rations | | | | | |
| 23 | 5 | 20 | 1.12–2.07 | 81.5 | 1.70 |
| 24 | 8 | 20 | 0.56–3.07 | 79.1 | 4.88 |
| 25 | 5 | 40 | 1.09–1.91 | 74.4 | 5.33 |
| Experiment 5: Mixed concentrate—hay rations | | | | | |
| With early-cut hay | | | | | |
| 26 | 11 | 100 | 1.06–2.50 | 65.7 | 1.87 |
| 27 | 10 | 75 | 1.20–2.41 | 70.0 | 2.86 |
| 28 | 8 | 50 | 1.03–2.31 | 71.2 | 0.95 |
| 29 | 13 | 25 | 1.03–2.25 | 73.8 | 3.57 |
| With late-cut hay | | | | | |
| 30 | 4 | 100 | 1.05–1.69 | 48.5 | 2.51 |
| 31 | 4 | 75 | 1.27–1.83 | 57.0 | 3.37 |
| 32 | 5 | 50 | 1.23–1.95 | 64.8 | 1.76 |
| 33 | 5 | 25 | 1.18–1.84 | 71.7 | 1.91 |

[a] Symbols designate the following intakes of dry matter (gm./day): L, 700; M, 1000; H, 1200.
[b] Values are intake levels expressed as multiples of the maintenance intake.
[c] Digestibility expressed on basis of following criteria for various experiments: Experiments 1, 2 and 4, digestible dry matter; Experiment 3, total digestible nutrients; Experiment 5, digestible energy.

relationship was found between the level of intake and the TDN value of the hay fed in trial 22.

The data obtained in Experiments 1, 2 and 3 confirm the view that the amount of long or chopped forage consumed does not affect digestibility. It seems possible that the physical nature of long or chopped forage (not containing grains) prevents an intake of forage by the animal which would depress digestibility. Possibly because its physical nature promotes a greater intake and a more rapid rate of passage through the gut, finely ground forage suffers greater fecal losses as observed by Blaxter and Graham (1956).

In Experiment 4 the level of intake of the two mixed diets studied had a variable effect upon the digestibility of the dry matter. There was no effect observed in trial 23 whereas increasing intakes markedly depressed digestibility in trials 24 and 25. The coefficients of correlation between these two variables were —.99 in trial 24 and —.96 in trial 25. The regression coefficients were 4.97 and 9.64, respectively. In trial 24 the digestibility of the dry matter decreased from 85.7% at an intake of 0.5 times maintenance to 74.3% at the highest level (2.7 times maintenance) studied. In trial 25 the digestibility declined from 78% at an intake of 1.0 times maintenance to 69% at 2.0 times maintenance. These data indicate that animals may derive 8 to 25% less digestible matter from high-concentrate rations consumed at production levels of intake (2.0 to 3.0 times the maintenance level) than from the same rations consumed at the maintenance level.

Experiment 5 was conducted to study the effect of the level of intake upon the DE value of two forages when each was fed alone and in combination with various proportions of concentrates. The DE value ($65.7 \pm 1.23\%$) of the hay harvested on May 29 was markedly higher than that ($48.5 \pm 1.23\%$) of the hay cut from the same source on July 9. In an analysis of variance it was found that increasing proportions of concentrates in the ration significantly increased the DE value of the rations containing both the early-cut and late-cut hays ($P<0.01$). However, the level of intake (of the total rations) did not affect the DE value of the rations containing either the early-cut hay ($0.2<P<0.3$) of the late-cut hay ($0.3<P<0.4$).

It is interesting to note in the data obtained in Experiment 5 that the extrapolation of the regression of the TDN value on the percentage of forage in the ration to 0% forage (or, conversely, to 100% concentrates) gives the values 75% and 80% TDN, respectively, for the same concentrate feed when fed with the early-cut and late-cut hays.

The present data do not explain the variable effect of plane of nutrition obtained in Experiments 4 and 5. Fundamental studies are needed to determine the conditions under which digestibility is depressed by increasing intake. The present studies indicate that the effect is not caused solely by the feeding of high-concentrate rations. A condition which might pos-

sibly effect the responses obtained is the difference in the age of the steers used in the two experiments. Hansson (1956) reported that the digestibility of a mixed ration by young, growing, non-pregnant heifers was the same when the ration was consumed at levels equivalent to 60, 80, 100, 120, and 140% as much feed as is recommended in the Scandinavian Standards. It remains for further studies to determine whether plane of nutrition has less effect upon digestibility by young, growing animals than upon that by more adult animals.

## Summary

A series of 33 digestion experiments was conducted in which the effect of level of intake upon the digestibility of forages and mixed diets was studied.

Within the ranges of intake examined, the digestibility of fresh, green forages by wethers and of hays by steers was not affected by the level of intake.

In two experiments with steers the digestibility of mixed diets markedly decreased as the level of consumption increased. However, the digestibility by steers of one of the same and two other mixed diets was not affected by the level of intake. Although the data obtained do not provide an explanation for the difference in the responses obtained, it was noted that the experiments in which digestibility was depressed by increasing intakes were those in which older animals were employed. However, the depression in digestibility of one ration was greater for younger than for older steers.

Further evidence is presented to demonstrate the marked decline in the digestible energy value of first-growth forages as growth approaches maturity. Also, it was found that the very best aftermath forage has a lower digestible energy value than early-spring, first-growth forage.

Limited data are presented which suggest that the TDN value of concentrates is greater when concentrates are fed with late-cut forage than with early-cut forage.

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# FERTILIZATION RATE AND EARLY EMBRYO SURVIVAL IN SHEARED AND UNSHEARED EWES FOLLOWING EXPOSURE TO ELEVATED AIR TEMPERATURE [1]

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FOR production of spring lambs, in many areas, ewes must conceive during a period of the year when hot weather frequently prevails, and producers experience difficulty in getting ewes uniformly settled. Recent investigations of the causes of reproductive failure in sheep early in the breeding season have suggested that a major factor is lowered fertility of rams (Dutt, 1954; Hulet *et al.*, 1956; Dutt and Simpson, 1957). Dutt and Bush (1955) and Dutt and Simpson (1957) have shown that fertility in sheep is improved early in the season when rams are kept at cooler temperatures during the summer months.

The frequent occurrence of morphologically abnormal ova early in the breeding season has been reported by Dutt (1954) and Hulet *et al.* (1956). This and the estimates of high embryonic loss reported by Dutt (1954) and Dutt and Simpson (1957) would lead one to suspect that certain factors causing lowered fertility early in the season may be associated with the female reproductive system. Andrews (1953) has reviewed the literature on the influence of environment on reproduction in female farm animals, and there appear to be few quantitative data on the specific effects of temperature.

The present study was designed to investigate the effects of high environmental temperature on the breeding performance of ewes. Sheared and unsheared ewes were exposed to elevated temperature and the effects on estrus and the estrual cycle, fertility rate, morphology of ova, and embryo loss in ewes exposed to heat before or after breeding were studied.

## Materials and Methods

The ewes to be treated in this study were placed in a hot room where the temperature was maintained constantly at 90° F. with not more than a variation of 2° and with the relative humidity maintained at 60%. Conditions in the heated room were similar to those found to impair spermatogenic activity in rams, after exposure of one week (Dutt and Hamm, 1957). A more detailed description of this chamber is given by Dutt and Bush (1954).

One-hundred twenty dark-faced, crossbred, yearling Northwestern ewes were included in the study, which was conducted during two breeding

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published with approval of the Director.

seasons because of the limited area of the hot room. In both years the ewes were removed from pasture in October and were kept in an open barn with an outside dry lot except when the treated groups were in the hot room. Time of estrus was determined by checking the ewes daily with aproned teaser rams. A ewe was considered to be in estrus when she would stand and allow a ram to mount.

In the fall of 1955 time of estrus was determined in 30 ewes, which were then randomly assigned to three groups of ten ewes each. One group served as a control and was kept in the open-sided barn. Ewes in the second and third groups were placed in the hot room 12 days after onset of the last estrual period. In the second group the ewes were sheared just before being placed in the heated room, and ewes in the third group remained unsheared. Ewes in the three groups were bred at the first estrus exhibited subsequent to assignment to the experimental groups and were slaughtered 3 days later to provide information on fertility.

Thirty additional ewes were bred contemporaneously with the slaughtered ewes and were randomly divided into three groups. One group of ten ewes served as controls and remained in the open-sided barn. Twenty of the ewes were placed in the hot room 8 days after breeding. Ten of these ewes were sheared just before being placed in the heated room and ten remained unsheared. It was postulated that a critical period in the development of the young embryo of sheep might occur at the time when the corpus luteum either regresses or becomes a corpus luteum of pregnancy or at the time of uterine attachment. The eight-day sheep embryo has reached the blastular stage and has not attached itself to the uterine wall (Green and Winters, 1945). Regression of the corpus in the nonpregnant ewe begins on about the 12th day of the estrual cycle (Warbritton, 1934).

Ewes on the embryo-survival study were kept in the hot room for a period of 16 days. All groups were checked daily for return to estrus by aproned teaser rams. Twenty-four days after breeding the treated ewes were removed from the hot room and placed with the control ewes. An observational laparotomy was performed 32 to 35 days after breeding on the ewes not returning to estrus within this period, and all ewes were retained for lambing information.

The study in the fall of 1956 was undertaken to determine the extent of embryo loss in ewes exposed to elevated temperature before breeding. Accordingly, time of estrus was determined in 60 ewes randomly assigned to three groups of 20 ewes each. One group of 20 ewes served as controls. As in the previous year, ewes in the second group were sheared, those in the third group remained unsheared and the ewes in these two groups were placed in the hot room 12 days after onset of estrus. The ewes in all groups were bred at the first estrus exhibited subsequent to assignment to the experimental groups. Ten ewes from each group were randomly selected and slaughtered 3 days after breeding for fertility data. The remaining ten ewes in each group were retained for an estimate of embryo

loss. All ewes were checked for return to estrus. Twenty-four days after breeding the ewes in the hot-room were removed and placed with the control ewes. Ewes not returning to estrus within 32 to 35 days after breeding were laparotomized to determine whether they were pregnant. All ewes were retained to lambing time.

In order to afford opportunity for maximum fertility and to minimize differences which might result from breeding to different rams, all ewes were artificially inseminated with 0.5 cc of fresh undiluted semen pooled from at least three rams of proven fertility. This procedure tended to standardize the ram's influence on fertility among all experimental ewe groups. For all inseminations semen was collected with an artificial vagina and from microscopic examination was judged to be of high quality. Each ewe was inseminated only one time, in the late afternoon of the first day of estrus, regardless of duration of the estrual period. In both years all breeding was done during November or the first week in December, a period during which breeding efficiency in sheep is normally high.

Upon slaughter the reproductive tracts were removed and taken to the laboratory. The number of ovulations was recorded and ova were recovered by flushing the oviducts with Krebs solution. After the ova were located in the flushing by means of a dissecting microscope, they were transferred to a hanging drop slide and examined under high power magnification for cleavage and evidences of morphological abnormality. When the ova were not cleaved, an examination was made for patency of the cervix and uterine horns.

As a measure of stress imposed upon the ewes by the temperature in the hot room, rectal temperature, respiration and pulse rates were recorded on five ewes from each group during both years. These records were thus taken on 60 ewes between 1 p.m. and 3 p.m. on the fourth day after the treated ewes had been placed in the hot room.

## Results

*Duration of Treatment Estrus and Length of Estrual Cycle.* Data for duration of estrus and length of estrual cycle are combined for the two years. Average duration of the subsequent estrus for the control ewes and for sheared and unsheared ewes placed in the hot room on the 12th day after onset of estrus is shown in table 1. The group means were tested by analysis of variance and were found not to differ significantly.

Average lengths of estrual cycle for the control, sheared and unsheared groups were 16.2, 16.8 and 17.1 days, respectively (table 1). Ewes in the hot room tended to have longer interestrual periods. The difference in the length of the cycle between the control and the sheared ewes was significant ($P<0.05$), and the difference between the control and the unsheared ewes was highly significant ($P<0.01$). All of the ewes came into estrus within a period of 20 days from the onset of their previous heat period.

TABLE 1. AVERAGE VALUES WITH STANDARD ERRORS FOR DURATION OF ESTRUS AND LENGTH OF ESTRUAL CYCLE FOR EWES PLACED IN HOT ROOM ON TWELFTH DAY AFTER ONSET OF ESTRUS

| Item | Control ewes | Hot-room ewes | |
|---|---|---|---|
| | | Sheared | Unsheared |
| Number of ewes | 30 | 30 | 30 |
| Duration of estrus, day | 1.9±.18 | 1.6±.16 | 1.8±.22 |
| Length of estrual cycle, day | 16.2±.13 | 16.8±.20* | 17.1±.28** |

* Mean significantly different from control ewes at 5% level.
** Mean significantly different from control ewes at 1% level.

The average interval to onset of estrus after they had been placed in the hot room was 5.7 days for the sheared group and 5.9 days for the unsheared group.

*Ovulation Rate.* All of the slaughtered ewes had ovulated as evidenced by the presence of at least one recently-formed corpus luteum and at least one ovum was recovered from each ewe. The ovulation rates for the slaughtered control, sheared and unsheared groups for the 1955 and the 1956 seasons are shown in table 2, and are not significantly different among the groups. A total of 79 ova were recovered from the 60 ewes, which represented 97.5% of the corpora lutea.

*Fertilization Rate.* Fertilization rates for the slaughtered ewes during the 1955 and 1956 seasons are shown in table 2. In control ewes for the two years 92.6% (25 out of 27) of the ova were cleaved. When data for the

TABLE 2. OVULATION AND FERTILIZATION RATES AND PERCENT MORPHOLOGICALLY ABNORMAL OVA FROM EWES EXPOSED TO ELEVATED TEMPERATURE BEFORE BREEDING

| Item | Year | Control ewes | Hot-room ewes | |
|---|---|---|---|---|
| | | | Sheared | Unsheared |
| Number of ewes | 1955 | 10 | 10 | 10 |
| | 1956 | 10 | 10 | 10 |
| Average number of corpora lutea | 1955 | 1.6 | 1.3 | 1.4 |
| | 1956 | 1.3 | 1.2 | 1.3 |
| Total ova recovered | 1955 | 14 | 13 | 14 |
| | 1956 | 13 | 12 | 13 |
| Ova fertilized, % | 1955 | 92.9 (13)[a] | 69.2 (9) | 42.9 (6) |
| | 1956 | 92.3 (12) | 58.3 (7) | 38.5 (5) |
| | Combined | 92.6 | 64.0* | 40.7*** |
| Abnormal ova, % | 1955 | 7.1 (1) | 15.4 (2) | 57.1 (8) |
| | 1956 | 0.0 | 50.0 (6) | 53.8 (7) |
| | Combined | 3.7 | 32.0** | 55.6*** |

[a] Numbers in parentheses denote number of ova.
* Significantly different from control ewes at 5% level.
** Significantly different from control ewes at 1% level.
*** Significantly different from control ewes at 0.1% level.

sheared hot-room ewes for the two years were combined, 64.0% (16 out of 25 ova) were cleaved, and for the unsheared hot-room ewes 40.7% (11 out of 27 ova) were cleaved. When the fertility rate of the sheared and unsheared hot-room ewes for the two years are combined, 51.9% (27 out of 52) of the ova were fertilized. Fertility in the hot-room ewes was significantly lower than for the control ewes when the data were tested by Chi-square.

*Abnormal Ova.* Part of the failure of fertilization appears to be due to an increase in morphologically abnormal ova in the ewes exposed to the elevated temperature. When examined under the microscope, ova with shrunken cytoplasm, enlarged cytoplasmic globules or vacuoles, ruptured vitelline membrane, broken zona pellucida or cleaved ova with fragmenting

TABLE 3. ESTIMATED EMBRYO LOSS AND LAMBING RESULTS IN EWES EXPOSED TO ELEVATED TEMPERATURE EIGHT DAYS POST-BREEDING

| Item | Control ewes | Hot-room ewes | |
|---|---|---|---|
| | | Sheared | Unsheared |
| Number of ewes | 10 | 10 | 10 |
| Number of ewes pregnant 32 to 35 days post-breeding | 10 | 10 | 9 |
| Number of ewes lambing | 10 | 10 | 7 |
| Number of lambs born | 14 | 14 | 8 |
| Average birth weight of lambs, lb. | 8.5 | 9.2 | 8.2 |
| Estimated embryo loss, % | 0[a] | 0[a] | 38.5[b] |

[a] $\frac{\text{13 fert. ova from control ewes (1955)—14 lambs born}}{\text{13 fert. ova from control ewes}} \times 100$, actually a minus value.

[b] $\frac{\text{13 fert. ova from control ewes (1955)—8 lambs born}}{\text{13 ova from control ewes}} \times 100$.

cells, were classified as abnormal. Photomicrographs of various types of abnormalities observed in sheep ova are shown by Dutt (1954) and Hart (1956). In the summarized data (table 2) no distinction is made between fertilized and unfertilized abnormal ova. Including both years only one ovum (3.7%) from the control group was classified abnormal. In the sheared hot-room ewes 32.0% (8 out of 25) of the ova were classified abnormal, and in the unsheared group 55.6% (15 out of 27) of the ova were abnormal. When the two hot-room groups were combined, 44.2% (23 out of 52) of the ova were classified abnormal. A significantly higher percentage of morphologically abnormal ova was found in the ewes that had been exposed to heat before breeding.

*Embryo Loss in Ewes Exposed to Elevated Temperature Eight-Days Post-breeding.* An estimate of embryo loss in ewes placed in the hot room 8 days post-breeding was calculated, using fertility data from the 1955 control ewes and the number of lambs born to the ewes placed in the hot room 8 days post-breeding. The estimated loss for both the control and the hot-room sheared ewes was calculated to be zero (table 3; actually, a

minus value was obtained). For the hot room unsheared ewes the embryo loss was calculated to be 38.5% (table 3). When the sheared and unsheared hot-room ewes are combined, the estimated embryo loss was calculated to be 15.4% (26 fertilized ova minus 22 lambs born/26 fertilized ova x 0.01). Nineteen of the 20 ewes in the hot room were pregnant when laparotomized 32 to 35 days post-breeding; however, only 17 ewes lambed. Embryo loss in the ewes exposed to the elevated temperature 8 days post-breeding was not significantly different from control ewes. The treatment had no significant effect on birth weight of the lambs. Yeates (1956) has reported lower birth weight for lambs from ewes exposed to elevated temperature part of each day during late pregnancy.

TABLE 4. ESTIMATED EMBRYO LOSS IN EWES EXPOSED TO ELEVATED TEMPERATURE BEFORE BREEDING

| Item | Control ewes | Hot-room ewes | |
|---|---|---|---|
| | | Sheared | Unsheared |
| Number of ewes | 10 | 10 | 10 |
| Number of ewes pregnant 32 to 35 days post-weaning | 8 | 1 | 0 |
| Number of ewes lambing | 8 | 1 | 0 |
| Number of lambs born | 10 | 1 | 0 |
| Estimated embryo loss, % | 16.7[a] | 85.7[b]** | 100.0[c]** |

[a] $\frac{\text{12 fert. ova from control slaughtered ewes (1956)—10 lambs born}}{\text{12 fert. ova from control slaughtered ewes}} \times 100.$

[b] $\frac{\text{7 fert. ova from slaughtered sheared ewes (1956)—1 lamb born}}{\text{7 fert. ova from slaughtered sheared ewes}} \times 100.$

[c] $\frac{\text{5 fert. ova from slaughtered unsheared ewes (1956)—no lambs born}}{\text{5 fert. ova from slaughtered unsheared ewes}} \times 100.$

** Significantly different from the control ewes at the 1% level.

*Embryo Loss in Ewes Exposed to Elevated Temperature before Breeding.* An estimate of embryo loss in ewes exposed to elevated temperature before breeding is available from the 1956 study. The number of fertilized ova from the slaughtered control, hot-room sheared and unsheared groups was compared with the number of lambs born in the respective groups of non-slaughtered ewes. These estimates are shown in table 4. Only one lamb was born to the 20 hot-room ewes, whereas 8 out of 10 control ewes lambed. Embryo loss in both the sheared and unsheared hot-room ewes, when tested by Chi-square, was significantly higher ($P<0.01$) than in the control ewes. Estimated embryo loss for the combined sheared and unsheared hot-room ewes was 91.7% (12 fertilized ova from slaughtered ewes—1 lamb born /12 fertilized ova x 0.01).

*Rectal Temperature and Pulse and Respiration Rates.* Average rectal temperature for the control ewes and for the sheared and unsheared ewes

four days after they were placed in the hot room is given in table 5. Both the sheared and unsheared groups had significantly higher ($P<0.01$) rectal temperatures than the control ewes.

Average respiration rates were 43.4 for the control ewes, 115.9 for the sheared ewes and 141.6 per minute for the unsheared ewes. Both sheared and unsheared ewes in the hot-room had significantly higher ($P<0.01$) respiration rates than the control ewes. Average pulse rate for the three groups ranged from 82.8 to 84.9 per minute, and did not differ significantly. Other than increased respiration, the ewes in the hot room exhibited no outward signs of discomfort; none was observed to go off feed. Air temperature in the open barn (where the control ewes were kept) at 12 noon, on the days when these records were taken, ranged from 29° F. to 53° F.

TABLE 5. AVERAGE VALUES AND STANDARD ERRORS FOR RECTAL TEMPERATURE, PULSE AND RESPIRATION RATES FOR CONTROL AND HOT-ROOM EWES[a]

| Item | Control ewes | Hot-room ewes | |
|---|---|---|---|
| | | Sheared | Unsheared |
| Rectal temperature, ° F. | 102.4± .08 | 104.2± .22** | 105.0± .23** |
| Respiration rate, per min. | 43.4±2.01 | 115.9±3.80** | 141.6±2.12** |
| Pulse rate, per min. | 82.8±1.36 | 82.7±1.70 | 84.9±1.09 |

[a] Each value is the average for a single observation on each of 30 ewes.
** Average significantly different from the control ewes at the 1% level.

## Discussion

Fertilization rate for control ewes in the present study was high, with an average for the two years of 92.6% of the ova showing cleavage. For the sheared and unsheared ewes exposed to the elevated temperature, the fertilization rate was 51.9%, and embryo loss in a similar group of unslaughtered ewes, estimated as the percent of fertilized ova that died, was 91.7%. Only one ewe out of 20 exposed to the heat before breeding eventually lambed. Some of the fertilized ova from ewes exposed to heat were classified as morphologically abnormal, which was probably an indication that death of the zygote or young embryo had already occurred within 3 days of breeding or before entering the uterus. Hart (1956) has also reported finding abnormal fertilized ova in sheep, but his data offer no estimation of subsequent embryo loss.

Comparing the embryo loss in the ewes exposed to the hot room before breeding with the loss in ewes exposed 8 days post-breeding, it seems clear that the older embryos were much less disturbed by the heat stress imposed in this study. Estimated embryo loss in the latter group of ewes was calculated to be only 15.4%, compared to an estimated embryo loss of 91.7% in ewes exposed to the heat before breeding. Estimated embryo loss in the control ewes during the two breeding seasons was calculated to be 4.0%

(25 fertilized ova—24 lambs born/25 fertilized ova x 0.01). Embryo loss in the control ewes was lower than reported for ewes early in the breeding season (Dutt, 1954; Hulet *et al.*, 1956; Dutt and Simpson, 1957). Hulet *et al.* (1956) reported a higher embryo loss in ewes bred before September 16 than in ewes bred later in the season.

The data unquestionably support the conclusion that fertility and development of the fertilized ovum while still in the oviduct are more susceptible to damage from external heat than is the eight-day-old embryo in the uterus. A significantly higher proportion of the embryos in ewes exposed to the elevated temperature on the eighth day of pregnancy implanted and developed normally. An earlier observation by Dutt (1954) that a cycle of normal length usually follows an infertile mating in ewes early in the season when embryo loss was estimated to be above 30% is indirect evidence that much of the embryo loss occurred at an early stage. Embryo losses at later stages of development would result in longer intervals to return of estrus.

This is not to imply that embryo loss does not occur at later stages during pregnancy. In the present study an estimate of ewes exposed to the heat in which there was complete loss of embryos between 32 to 35 days post-breeding and lambing time is calculated to be 10.0% (20 ewes pregnant at 32 to 35 days post-breeding vs. 18 ewes lambing). All of the control ewes pregnant at this state subsequently lambed. Exposure to heat resulted in longer interestrual periods, but had no effect on ovulation rate nor on occurrence or duration of estrus. Of the 19 ewes exposed to heat before they were bred and which subsequently failed to lamb, 18 returned to heat with an average cycle length of $16.8 \pm 0.21$ days. One ewe returned to estrus 34 days following breeding. The heat treatment appears not to have altered the cyclic rhythm.

The marked decrease in fertilization rate and the increase in abnormal ova in the treated ewes indicate a detrimental effect of heat upon the female reproductive system. It is possible that the elevated temperature resulted in endocrine disturbance. Evidence to support such a contention might be deduced from the longer estrual cycles in ewes exposed to the heat. There is also evidence that the increase in body temperature of the hot-room ewes may have resulted in a change in the environment within the female reproductive tract, so the sperm livability or travel was impaired. Fewer sperm cells were present in the zona pellucida of ova from the hot-room ewes than from control ewes. Also, a higher percentage of ova from the hot-room ewes contained no sperm cells at all. However, the higher percentages of abnormal ova (32.0% in sheared and 55.6% in unsheared ewes vs. 3.7% in control ewes) raises the question whether failure of fertilization was due to inability of the sperm cells to reach the ova or to their inability to penetrate initially defective ova. It is also probable that increase in body temperature (1.8° F. in sheared and 2.6° F. in unsheared ewes) in the ewes exposed to the heat had a damaging effect *per se*

upon the gametes. Answers to the mode of action of the deleterious effects on fertilization rate in ewes exposed to elevated temperature must await further study.

Of practical consideration is the association between exposure to heat and shearing and the effect upon reproductive efficiency. In all groups of sheared ewes exposed to the heat, fertility was higher, the percentage of abnormal ova was lower and embryo survival rate was higher than for the unsheared ewes. For any single factor the difference between the sheared and unsheared group was not statistically significant. However, when all the above facets which affect reproductive efficiency are considered, the difference due to shearing may be quite important as the temperature approaches a critical level. Removing the wool (fleece weights ranged from 5 to 7 lb.) resulted in lower rectal temperatures and pulse rates in ewes exposed to the heat and was partially effective in alleviating the stress imposed upon the ewes.

That fertility is decreased and the incidence of morphologically abnormal ova increased in ewes exposed to elevated ambient temperature before breeding is of considerable interest in view of the early season infertility observed in sheep. It may be that the reproductive losses early in the season in ewes are due to factors other than high environmental temperature. Exposing females to elevated temperature has been shown to be harmful to successful reproduction in certain species. Yeates (1953) has reported an adverse effect of high temperature during gestation in ewes. Similarly, Sundstroem (1927) in studies with rats and Ogle (1934) with mice reported hot-room treatment resulted in small litters. When the harmful effects of elevated environmental temperature upon reproductive performance in ewes are partitioned, they appear to be far greater upon fertilization rate and survival of the embryo prior to and during the early blastocyst stage, than upon estrual rhythm, ovulation rate or embryo survival at later stages in pregnancy.

These findings raise the question as to whether some of the seasonal differences in fertility reported for cattle might be due in part to changes in physiological environment within the female reproductive system rather than due entirely to changes in fertility level of the bull (Seath and Staples, 1941; Hilder *et al.*, 1944; Mercier and Salisbury, 1946).

## Summary

Fertilization rate in ewes exposed to elevated air temperature (90° F.) on the 12th day of the cycle before breeding was significantly lower ($P<0.01$) than for control ewes. During two breeding seasons 92.6% of ova from control ewes were cleaved, compared to 51.9% from ewes in the hot room. The heat treatment resulted in an increase in the percentage of abnormal ova. Only 3.7% of ova from control ewes examined 3 days after

breeding were classified as morphologically abnormal, compared to 44.2% from ewes in the hot room.

Embryo loss, estimated as the percent of fertilized ova that died, was significantly higher in ewes exposed to the heat before breeding. For control ewes during two breeding seasons, the estimated embryo loss was 4.0% compared to an estimated loss of 91.7% for ewes exposed to the heat before breeding.

When ewes were not exposed to the heated room until 8 days post-breeding, the estimated embryo loss (15.4%) was not significantly different from control ewes. Seventeen out of 20 ewes lambed when bred and exposed to the heat 8 days later, compared to only one out of 20 ewes when exposed to the heat before breeding. Fertilization rate and survival of the early embryo in ewes appear to be more susceptible to heat damage than is the 8-day embryo.

Birth weights of lambs from ewes exposed to heat from the 8th through the 24th day post-breeding did not differ significantly from control lambs.

Rectal temperatures and pulse rates of the ewes in the hot room were significantly increased ($P<0.01$) over control ewes. The hot-room sheared ewes had lower average rectal temperature and pulse rate than the unsheared ewes.

The adverse effect of heat on fertilization rate, percentage of abnormal ova and embryo loss was less severe when ewes were sheared before they were exposed to the elevated temperature.

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# DIETHYLSTILBESTROL AND LENGTH OF PRELIMINARY PERIOD IN THE UTILIZATION OF CRUDE BIURET AND UREA BY LAMBS

## I. Digestion and Nitrogen Retention

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CRUDE biuret, a commercially available mixture of biuret, urea, triuret and cyanuric acid, would appear to possess certain advantages as a substitute for urea in ruminant feeding. This NPN mixture is readily soluble in water, contains (40%) nitrogen and has been shown to be non-toxic to ruminants (Berry, Riggs and Kunkel, 1956). There is, however, some question as to the extent of its utilization by ruminants. Meiske *et al.* (1955) reported crude biuret to be utilized as well as urea by growing-fattening lambs, but Berry, Riggs and Kunkle (1956) found it to exert a depressant effect on the appetites of lambs and steers, and on the gains in body weight of steers.

According to the work of Gaither *et al.* (1955) biuret nitrogen was retained as well as urea nitrogen. In contrast to these results, digestion and nitrogen metabolism data reported by Anderson *et al.* (1959) indicated that crude or pure biuret is not utilized as well by lambs as is urea.

Although Lloyd, Peckham and Crampton (1956) substantiated the validity of the general practice of using 10-day preliminary periods in digestion and nitrogen metabolism trials with sheep fed natural rations, the work of Repp *et al.* (1955) suggests that longer preliminary periods may be required to permit lambs to adjust to NPN supplemented rations. The length of time allowed for lambs to adjust to the utilization of NPN compounds was 37 days in the work reported by Gaither *et al.* (1955) and 15 days in the work reported by Anderson *et al.* (1959). This factor may account for the differences in the utilization of biuret reported by these two groups of workers.

Bell *et al.* (1957) have shown that diethylstilbestrol (DES) increased the retention of nitrogen when fed to lambs receiving rations containing urea.

The purpose of the work described in this report was to determine the influence of DES and time, and the possible relationship between these factors, upon the utilization of nitrogen by lambs fed crude biuret- and urea-supplemented rations.

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## Experimental Procedure

Two digestion and nitrogen metabolism trials were conducted with grade Hampshire wether lambs weighing between 33 and 38 kg. The lambs were fed semi-purified rations containing approximately 1.6% nitrogen, two-thirds of which was supplied by NPN sources. Rations were composed of wheat straw, cane molasses and concentrate mixtures which varied only in the NPN source.

The lambs were drenched with phenothiazine and lead arsenate before being placed in the metabolism stalls. The metabolism stalls were built according to the description of Briggs and Gallup (1949) with the modifications noted by Anderson *et al.* (1959).

After a period of 5 days lambs in both trials were adjusted to a constant daily feed intake of 810 gm., fresh basis. They were maintained at this level for at least a 10-day preliminary period which was followed by a 10-day collection period. Feeds, feces and urine were sampled and stored as described by Smith *et al.* (1957) and analyses for proximate constituents were made according to A.O.A.C. methods (1950). Data were analyzed for variance according to Snedecor (1946).

*Trial 1.* Three rations were used in this trial. The only differences among these rations were the sources of supplementary NPN which were: (1) urea, 100%, (2) urea, 50% and crude biuret, 50% and (3) crude biuret, 100%. In this and subsequent trials the NPN materials under study contributed 67% of the total ration nitrogen. The constituents and compositions of these rations are presented in table 1.

Four lambs were randomly assigned to each of the three rations. Two of these were then selected at random from each ration group to receive 2 mg. of DES per head daily as a constituent of the concentrate mixture. The trial was designed so that 10-day collection periods were preceded by preliminary periods of 10, 15, and 35 days. Each lamb received the same NPN source during the entire trial, but after 25 days the DES treatment within each NPN group was reversed.

*Trial 2.* This trial was started 60 days after the completion of Trial 1. In the period between the two trials the lambs were fed, free-choice, a good quality grass hay and a trace mineralized salt. At the end of this period eight lambs were placed on the crude biuret ration described in table 1 for Trial 2. Four of these lambs were then randomly selected to receive 2 mg. of DES per day and the other four served as controls. After adjustment to the rations the lambs were placed on a 10-day preliminary period which was followed by five consecutive 10-day digestion and nitrogen metabolism periods or the equivalent of a 10-day digestion and nitrogen metabolism period preceded by preliminary periods of 10, 20, 30, 40 and 50 days.

TABLE 1. AVERAGE DAILY AMOUNTS AND PERCENTAGE COMPOSITION OF RATIONS

| Item | Ration designation according to NPN source | | | |
|---|---|---|---|---|
| | 100% urea | 50% urea 50% crude biuret | 100% crude biuret | 100% crude biuret |
| Trial number | 1 | 1 | 1 | 2 |
| Ration constituents, gm. | | | | |
| Wheat straw | 440.0 | * | * | * |
| Cane molasses (78% solids) | 170.0 | * | * | * |
| Concentrate mixture | 200.0 | * | * | * |
| Purified soybean protein [a] | 13.2 | * | * | * |
| Urea | 18.4 | 9.2 | .... | .... |
| Crude biuret [b] | .... | 9.2 | 18.4 | 18.4 |
| Corn starch | 76.0 | * | * | * |
| Dextrose | 32.4 | * | * | * |
| Corn oil | 29.4 | * | * | * |
| Mineral mixture [c] | 27.3 | * | * | * |
| Vitamin A-D oil [d] | 2.6 | * | * | * |
| Choline | 0.7 | * | * | * |
| Vitamin supplement [e] | .... | ... | ... | ... |
| Total, gm. | 810.0 | * | * | * |
| Composition, dry matter basis, % | | | | |
| Organic matter | 92.57 | 92.75 | 92.72 | 93.35 |
| Protein (N×6.25) | 9.57 | 9.62 | 9.66 | 10.20 |
| Ether extract | 5.12 | 5.14 | 5.16 | 5.12 |
| Crude fiber | 25.22 | 24.97 | 25.10 | 24.79 |
| N-free extract | 52.66 | 53.02 | 52.80 | 53.24 |

* Indicates same amount as in the 100% urea-supplemented ration fed in Trial 1.

[a] Drackett assay protein C–1. The Drackett Products Company, Cincinnati 32, Ohio.

[b] A mixture containing biuret (40.0%), urea (45.5%), triuret (6.7%), cyanuric acid (7.6%) and water (0.3%). The crude biuret and feeding urea was supplied by Allied Chemical and Dye Corp., Nitrogen Div., N. Y., N. Y.

[c] Composition of mineral mixture as given by Thomas *et al.* (1951).

[d] Nopco XX; National Oil Products Company, Harrison, New Jersey; stated to contain not less than 2250 USP units of vitamin A and 300 IC units of vitamin D per gram.

[e] Two hundred grams of concentrate mixture contained 1.8 mg. each of thiamine and riboflavin and 8.0 mg. of alpha tocopherol. These materials were supplied by L. Michaud, Animal Research Division, Merck, Sharp, and Dohme, Rahway, New Jersey.

## Results

*Digestibility.* Digestion data obtained in Trial 1 are presented in table 2. The analyses of variance of these data and of all digestion and nitrogen retention data of Trials 1 and 2 are presented in table 6. From these results it may be seen that replacement of one half or all of the supplemental urea with crude biuret resulted in a highly significant ($P<.01$) depression in digestibility of organic matter and crude fiber and apparent

TABLE 2. THE EFFECT OF NPN SOURCE, DES, AND LENGTH OF PRELIMINARY PERIOD ON NUTRIENT DIGESTION

TRIAL 1

| Ration designation | Days on NPN supplemented ration | Average weight of lambs | Dry matter intake | Ration protein (N×6.25) | Digestibility of nutrients[a] | | |
|---|---|---|---|---|---|---|---|
| | | | | | Organic matter | Protein (N×6.25) | Crude fiber |
| | | kg. | gm. | % | % | % | % |
| 100% urea | 10 | 34.3 | 730 | 9.33 | 61.2 | 65.8 | 51.7 |
| " " | 15 | 34.3 | 728 | 9.38 | 62.0 | 66.8 | 53.0 |
| " " | 35 | 35.0 | 724 | 9.32 | 61.3 | 67.5 | 48.2 |
| 100% urea & DES | 10 | 34.3 | 728 | 9.75 | 58.9 | 66.6 | 46.4 |
| " " " | 15 | 34.3 | 728 | 9.81 | 58.4 | 66.8 | 45.4 |
| " " " | 35 | 35.4 | 728 | 9.76 | 62.1 | 69.6 | 51.7 |
| Means, 100% urea supplement ration | | | | | 60.7 | 67.2 | 49.4 |
| 50% urea, 50% crude biuret | 10 | 33.9 | 730 | 9.53 | 56.6 | 60.6 | 42.3 |
| " " " " " | 15 | 33.9 | 727 | 9.60 | 56.6 | 62.6 | 42.3 |
| " " " " " | 35 | 36.5 | 724 | 9.92 | 61.3 | 70.1 | 49.6 |
| 50% urea, 50% crude biuret & DES | 10 | 36.4 | 729 | 9.42 | 59.2 | 65.0 | 47.5 |
| " " " " " " | 15 | 36.4 | 727 | 9.48 | 59.1 | 66.9 | 46.8 |
| " " " " " " | 35 | 33.3 | 724 | 9.88 | 56.3 | 64.1 | 40.4 |
| Means, 50% urea, 50% crude biuret supplemented ration | | | | | 58.2* | 64.9* | 44.8* |
| 100% crude biuret | 10 | 34.7 | 730 | 9.44 | 59.6 | 58.4 | 44.7 |
| " " " | 15 | 34.7 | 728 | 9.50 | 59.7 | 60.6 | 46.3 |
| " " " | 35 | 36.8 | 724 | 9.31 | 59.6 | 63.8 | 47.8 |
| 100% crude biuret & DES | 10 | 36.2 | 728 | 9.91 | 57.2 | 62.5 | 46.0 |
| " " " " | 15 | 36.2 | 727 | 9.97 | 58.8 | 63.3 | 47.6 |
| " " " " | 35 | 35.0 | 727 | 9.70 | 57.2 | 61.6 | 42.0 |
| Means, 100% crude biuret supplemented ration | | | | | 57.7* | 61.7** | 45.7* |

[a] Two lambs were used on each treatment.
* P<.05 (Between urea and levels of crude biuret).
** P<.01 (Between urea and levels of crude biuret).

TABLE 3. THE EFFECT OF DES AND LENGTH OF PRELIMINARY PERIOD ON DIGESTION IN LAMBS FED CRUDE BIURET SUPPLEMENTED RATIONS

TRIAL 2

| Additive | Length of preliminary period | Average weight of lambs | Dry matter intake daily | Ration protein (N×6.25) | Digestibility of nutrients[a] | | |
|---|---|---|---|---|---|---|---|
| | | | | | Organic matter | Protein (N×6.25) | Crude fiber |
| | days | kg. | gm. | % | % | % | % |
| None | 10 | 35.3 | 724 | 10.45 | 62.6 | 70.5 | 51.8 |
| " | 20 | 35.3 | 721 | 10.32 | 63.5 | 70.2 | 53.0 |
| " | 30 | 35.3 | 725 | 10.24 | 64.1 | 70.5 | 53.7 |
| " | 40 | 36.2 | 728 | 10.24 | 64.9 | 71.5 | 53.9 |
| " | 50 | 36.2 | 726 | 10.20 | 63.6 | 71.1 | 53.9 |
| Mean | | | | | 63.7 | 70.8 | 53.3 |
| 2 mg. DES/day | 10 | 34.5 | 724 | 10.45 | 61.8 | 68.5 | 50.8 |
| " " " | 20 | 34.5 | 721 | 10.32 | 60.9 | 68.2 | 51.3 |
| " " " | 30 | 34.5 | 725 | 10.24 | 62.9 | 70.3 | 51.3 |
| " " " | 40 | 35.0 | 728 | 10.05 | 61.1 | 69.5 | 48.1 |
| " " " | 50 | 35.0 | 727 | 10.01 | 62.3 | 70.4 | 50.8 |
| Mean | | | | | 61.8* | 69.4* | 50.5** |

[a] Four lambs were used per treatment and period.
* P<.05 (Between DES treatment means).
** P<.01 (Between DES treatment means).

digestibility of protein. The digestibility of these nutrients was not significantly influenced by orally administered DES. Extension of the preliminary period beyond 10 days resulted in a highly significant ($P<.01$) increase in the apparent digestibility of protein but not of organic matter or crude fiber in all three rations.

Digestion data obtained in Trial 2 during 10-day collection periods following preliminary periods of 10, 20, 30, 40, and 50 days are presented

TABLE 4. THE EFFECT OF NPN SOURCE, DES AND LENGTH OF PRELIMINARY PERIOD ON NITROGEN METABOLISM

TRIAL 1

| Ration designation | Days on NPN supplemented ration | Nitrogen intake | Fecal nitrogen | Urinary nitrogen | Nitrogen balance | Absorbed nitrogen retained[a] |
|---|---|---|---|---|---|---|
| | | gm. | gm. | gm. | gm. | % |
| 100% urea | 10 | 10.90 | 3.70 | 7.17 | 0.03 | 41.8 |
| " " | 15 | 10.93 | 3.62 | 6.94 | 0.37 | 44.6 |
| " " | 35 | 10.80 | 3.51 | 5.87 | 1.42 | 54.9* |
| 100% urea & DES | 10 | 11.37 | 3.80 | 6.17 | 1.40 | 53.1 |
| " " " | 15 | 11.43 | 3.79 | 5.89 | 1.75 | 56.0 |
| " " " | 35 | 11.29 | 3.57 | 5.86 | 1.86 | 56.9 |
| Mean—100% urea supplemented ration | | | | | | 51.2 |
| 50% urea, 50% crude biuret | 10 | 11.13 | 4.44 | 6.43 | 0.26 | 46.2 |
| " " " " " | 15 | 11.17 | 4.24 | 6.34 | 0.59 | 48.3 |
| " " " " " | 35 | 11.49 | 3.44 | 6.31 | 1.74 | 54.4* |
| 50% urea, 50% crude biuret & DES | 10 | 10.97 | 3.85 | 6.75 | 0.37 | 46.1 |
| " " " " " " | 15 | 11.03 | 3.65 | 6.60 | 0.78 | 48.7 |
| " " " " " " | 35 | 11.43 | 4.11 | 5.49 | 1.83 | 58.2* |
| Mean—50% urea, 50% crude biuret supplemented ration | | | | | | 50.3 |
| 100% crude biuret | 10 | 11.03 | 4.58 | 6.40 | 0.05 | 45.5 |
| " " " | 15 | 11.06 | 4.37 | 6.32 | 0.37 | 47.6 |
| " " " | 35 | 10.78 | 3.92 | 6.16 | 0.70 | 50.6 |
| 100% crude biuret & DES | 10 | 11.54 | 4.34 | 6.33 | 0.87 | 50.5 |
| " " " " | 15 | 11.60 | 4.25 | 5.96 | 1.39 | 54.7 |
| " " " " | 35 | 11.24 | 4.27 | 5.87 | 1.10 | 53.6 |
| Mean—100% crude biuret supplemented ration | | | | | | 50.4 |

[a] Two lambs per treatment.
* $P<.05$ (Between periods within DES treatment groups).

in table 3. The digestibility of organic matter and crude fiber and apparent digestibility of protein was not influenced by the length of the preliminary period. DES exerted a highly significant ($P<.01$) depression on the digestibility of these nutrients.

*Nitrogen Utilization.* Nitrogen retention data obtained in Trial 1 are presented in table 4. In contrast to the significant depressant effect of crude biuret upon digestibility, the level of this material in the ration did not decrease the percentage of absorbed nitrogen retained. But, increasing the length of the preliminary period beyond 10 days or supplementing the ration with DES resulted in a highly significant ($P<.01$) increase in the retention of absorbed nitrogen.

It should be noted that the term "percentage of absorbed nitrogen retained" is equivalent to the term "biological value" obtained by means of the Thomas-Mitchell equation. Use of the former term seems to be preferred in expressing the utilization of nitrogen by ruminants fed rations containing high percentages of NPN. Values for metabolic fecal nitrogen and endogenous urinary nitrogen required in the Thomas-Mitchell equation were 0.435 gm. N per 100 gm. dry matter intake and 0.033 gm. N per kg. body weight, respectively. These values were obtained with lambs fed rations similar in composition to those fed in Trials 1 and 2, except

TABLE 5. THE EFFECT OF DES AND LENGTH OF PRELIMINARY PERIOD ON NITROGEN METABOLISM IN LAMBS FED CRUDE BIURET SUPPLEMENTED RATIONS

TRIAL 2

| Ration additive | Length of preliminary period | Nitrogen intake | Fecal nitrogen | Urinary nitrogen | Nitrogen balance | Absorbed nitrogen retained[a] |
|---|---|---|---|---|---|---|
| | days | gm. | gm. | gm. | gm. | % |
| None | 10 | 12.11 | 3.59 | 8.12 | 0.40 | 40.4 |
| " | 20 | 11.91 | 3.56 | 7.78 | 0.57 | 42.4 |
| " | 30 | 11.88 | 3.51 | 7.49 | 0.88 | 45.1 |
| " | 40 | 11.93 | 3.51 | 7.38 | 1.04 | 46.6* |
| " | 50 | 11.86 | 3.47 | 6.96 | 1.43 | 50.0* |
| Mean | | | | | | 44.9 |
| 2 mg. DES/day | 10 | 12.11 | 3.82 | 7.56 | 0.73 | 43.9 |
| " " " | 20 | 11.91 | 3.79 | 7.27 | 0.85 | 45.6 |
| " " " | 30 | 11.88 | 3.53 | 6.91 | 1.44 | 49.8* |
| " " " | 40 | 11.69 | 3.53 | 7.00 | 1.16 | 48.4 |
| " " " | 50 | 11.63 | 3.47 | 6.96 | 1.20 | 48.8 |
| Mean | | | | | | 47.4† |

[a] Four lambs were used per treatment and period.
* $P<.05$ L.S.D.$<.05$ between periods$=5.39$.
† DES vs. no DES, $P<.08$.

that the nitrogen content was reduced to 0.28% by the removal of the Drackett protein and NPN supplements.

The nitrogen retention data of Trial 2 are presented in table 5. These results indicate that the retention of absorbed nitrogen is increased ($P<.01$) as a function of the length of the preliminary period. The retention of absorbed nitrogen by lambs fed DES was greater than that by the controls ($P<.08$).

*Discussion*

Although 10-day preliminary periods are generally regarded as adequate for the adjustment of ruminants to natural rations, growth data and *in vitro* studies reported by Repp *et al.* (1955) suggest that they may not be adequate when NPN compounds furnish most of the ration nitrogen. Nitrogen retention data obtained in Trials 1 and 2, representing eight collection periods indicate that some type of adaptation takes place in

ruminants fed rations of this type. Retention of absorbed nitrogen by lambs increased as a function of the length of the preliminary period. Maximal nitrogen retention was reached only after 30 to 40 days, however DES reduced this time to about 10 days.

Orally administered DES increased the retention of absorbed nitrogen in rations containing either urea or crude biuret. Story *et al.* (1955) and Bell *et al.* (1957) also showed that DES increased nitrogen retention in lambs.

Replacement of all or one-half of the urea in semi-purified rations with crude biuret resulted in a depression in the digestibility of nutrients but nitrogen retention was not affected.

TABLE 6. ANALYSIS OF VARIANCE OF DIGESTION AND NITROGEN METABOLISM DATA OBTAINED WITH LAMBS IN TRIALS 1 AND 2

| Trial | Source(s) of variation | Digestion coefficients | | | | Percentage of absorbed nitrogen retained | |
|---|---|---|---|---|---|---|---|
| | | d.f. | Organic matter m.s. | Protein (N×6.25) m.s. | Crude fiber m.s. | d.f. | m.s. |
| 1 | Periods (P) | 2 | 2.38 | 26.81** | 0.84 | 2 | 162.27** |
| | Biuret level (B) | 2 | 20.46* | 91.13** | 70.70** | 2 | 1.89 |
| | DES | 1 | 7.29 | 11.72 | 18.01 | 1 | 191.06** |
| | P×B | 4 | 1.62 | 1.53 | 3.97 | 4 | 15.20 |
| | P×DES | 2 | 2.63 | 22.80** | 13.87 | 2 | 11.76 |
| | B×DES | 2 | 2.30 | 0.41 | 8.99 | 2 | 33.23 |
| | Error | 22 | 3.07 | 3.60 | 12.71 | 22 | 14.58 |
| 2 | Periods (P) | 4 | 1.31 | 3.37 | 6.06 | 4 | 77.79** |
| | DES | 1 | 9.37** | 16.99* | 114.00** | 1 | 51.44*** |
| | P×DES | 4 | 8.09** | 1.60 | 6.72 | 4 | 9.47 |
| | Error | 30 | 1.97 | 4.06 | 7.44 | 30 | 13.78 |

* $P<.05$.
** $P<.01$.
*** $P<.08$.

The nature of the adaptation which occurs during prolonged preliminary feeding of NPN supplemented rations is not known. It may involve the establishment of a rumen flora having a greater capacity to utilize NPN for the synthesis of microbial protein, or it may result from various factors favoring better utilization of absorbed nitrogen by the animal's tissues.

It is well-known that upon changing an animal's dietary regimen from a high-protein to a low-protein ration the "deposit protein" nitrogen is at first excreted in the urine at a high level. Miller and Morrison (1942) have shown that urinary nitrogen in the ruminant reaches a constant level within 10 to 12 days after reducing the protein content of rations from 13% to 4.5%. In the work reported here the lambs were fed grass hay prior to receiving the NPN supplemented semi-purified ration containing approximately 10% protein equivalent. A total of at least 15 days, including a 10-day preliminary period, was allowed for the lambs to adjust to the semi-purified ration. This period should have been adequate for the lambs to adjust their protein stores but, in view of the data presented

in this report, the period was not sufficient for them to become adapted to the efficient use of NPN.

## Summary

Two digestion and nitrogen retention trials, one consisting of three successive 10-day collection periods, and another of five, were conducted with wether lambs to determine the effect of diethylstilbestrol (DES) and length of preliminary period upon the utilization of crude biuret- and urea-supplemented rations.

The utilization of absorbed nitrogen was increased by prolonging the preliminary period or supplementing the rations with DES. The replacement of urea nitrogen with crude biuret depressed the digestibility of organic matter and crude fiber and apparent digestibility of protein, but did not influence the percentage retention of absorbed nitrogen.

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# EFFECT OF EXOGENOUS PROGESTERONE ON THE CORPUS LUTEUM OF THE BRED EWE [1]

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EARLY embryonic death appears to be a major factor in the reproductive loss found in animals. Dutt (1954) estimated that embryonic death occurred in 20% of the ewes mated early in the breeding season. Hulet *et al.* (1956) reported embryonic loss in sheep as 20.4% during the first 18 days of pregnancy. Varying degrees of success in preventing embry-

TABLE 1. FERTILITY AND CORPUS LUTEUM CHARACTERISTICS OF EWES INJECTED WITH PROGESTERONE

| Day group | Days of experiment (Experimental-Group designations) 1–5 | 6–13 | 14–25 | No. ewes | Corpus luteum: Average weight | Corpus luteum: Percent cells [b] | Fertility [c] |
|---|---|---|---|---|---|---|---|
| 5[d] | U[a] | | | 6 | 325 | 37 | 87 |
| | T[a] | | | 5 | 231 | 42 | 80 |
| 13[d] | U | U | | 6 | 642 | 51 | 78 |
| | U | T | | 5 | 524 | 37 | 42 |
| | T | U | | 4 | 430 | 37 | 75 |
| | T | T | | 5 | 328 | 30 | 50 |
| 25[e] | U | U | U | 6 | 756 | 52 | 80 |
| | U | U | T | 5 | 647 | 44 | 87 |
| | U | T | U | 4 | 634 | 54 | 75 |
| | U | T | T | 5 | 436 | 54 | 70 |

[a] U=untreated, T=injected with 0.4 mg. progesterone daily per pound body weight.
[b] Expressed as mean of arc sines of "functional" cells.
[c] Percentage of corpora lutea represented by embryos (13- or 25-day) or recovered eggs that were fertilized (5-day).
[d] Corpora lutea studied at day-5 and day-13 are from both pregnant and non-pregnant ewes.
[e] Corpora lutea studied at day-25 are from pregnant ewes only.

onic death by injections of progesterone have been reported for cattle (Herrick, 1953; Dawson, 1954; Wiltbank *et al.*, 1956; Johnson *et al.*, 1958).

The action of additive progesterone therapy upon the presumed reciprocal relationships between the corpora lutea and factors which bring about the formation and maintenance of these glands needs exploration. The purpose of this experiment was to study the effect of high levels of progesterone injected for various periods during early pregnancy.

## Materials and Methods

Fifty-one mature ewes, 16 of native and 35 of western origin, were assigned at random to the 10 groups shown in table 1. Two of these groups

[1] Paper from the Department of Genetics No. 727 and Department of Animal Husbandry, published with the approval of the Director of the Agricultural Experiment Station, supported in part by the Research Committee of the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.

were slaughtered at five days after breeding, four at 13 days, and four at 25 days. The particular intervals during which injections were made for each treatment group are indicated in table 1. The ewes were checked for heat twice daily by vasectomized teaser rams, and handbred to one of two normal rams at random 12 hours after being found in heat. All intervals are expressed as elapsed days from the time the ewe was found in heat, the day of the beginning of heat being considered day-0.

Crystalline progesterone was dissolved in corn oil at a concentration of 25 mg. per ml. and subcutaneous injections were made daily. All injections were made on the basis of 0.4 mg. progesterone daily per pound of body weight, which was considered to be a high dose. Dutt and Casida (1948) showed that a total of 10 mg. daily per ewe was sufficient to inhibit ovulation and estrus. Foote *et al.* (1957) maintained pregnancy to the 25th day in ovariectomized ewes with daily injections of 0.2 mg. progesterone plus 0.05 mcg. estrone per pound of body weight.

The corpora lutea were removed from the ovaries after slaughter and weighed immediately to the nearest milligram in the fresh condition. A small portion was then removed from each corpus luteum and fixed in Bouin's solution for histological study. Sections were stained with haemotoxylin and eosin and studied under the oil immersion objective. The cells were classified into the five cell types as described by Foley and Greenstein (1958). According to this classification, types I and II are presumed to be "functional", whereas the other three types are interpreted as successive stages of regression.

The corpora lutea weights were adjusted for origin of ewe, western or native, and for number per ewe, single or twin ovulation. All adjustments were made to the basis of a western ewe with a single ovulation which was the most numerous kind. The adjustment factors were calculated as the weighted means of comparable differences from all day-experimental groups as described by Snedecor (1956) except that the weighting factor (w) was modified for twin ovulations. The factor used was equal to $\frac{(n_s)(n_t)}{(n_s)(1+r')+(n_t)}$ where $r'$ was the intraclass correlation of the weights of the two corpora lutea of ewes with twin ovulations; $n_s$ was equal to the number of corpora lutea observed in single ovulations per day-experimental group; and, $n_t$ was equal to the number of corpora lutea observed in twin ovulations (2 times the number of ewes with twin ovulations).[2] Then one corpus luteum from each ewe with twin ovulations was selected at random for statistical analysis. The type I and II cell counts were combined and their number expressed as a percentage of the total number of lutein cells. These percentages were then transformed to arc sines.

[2] The authors wish to express their appreciation to A. B. Chapman for derivation of the weighting factor and advice in its use.

## Results

Analysis of variance of the corpus luteum weights showed no statistically significant difference between the groups studied at day-5, but highly significant differences between the groups studied at day-13 and day-25.

At day-13, a multiple range statistical test (table 2) showed that both treatment groups in which injections were begun on day-1 had a lower average corpus luteum weight than the uninjected 13-day controls. The group treated from day-1 to -13 (TT) also had a significantly lower corpus luteum weight than the group treated from day-5 to -13 (UT). Corpora lutea of ewes from which an embryo was recovered were not different in

TABLE 2. MULTIPLE RANGE TEST [a] OF CORPUS LUTEUM CHARACTERISTICS

| Weight—Compared within day group | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Day group | 5 | | 13 | | | | 25 | | | |
| Experimental group | T | U | TT | TU | UT | UU | UTT | UTU | UUT | UUU |
| Mean | 231 | 325 | 328 | 430 | 524 | 642 | 436 | 634 | 647 | 765 |

| Percent "functional" cells—Expressed as arc sines | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Day | 13 | 13 | 5 | 13 | 5 | 25 | 13 | 25 | 25 | 25 |
| Experimental group | TT | TU | U | UT | T | UUT | UU | UUU | UTT | UTU |
| Mean | 30 | 37 | 37 | 37 | 42 | 44 | 51 | 52 | 54 | 54 |

[a] Any two means underscored by the same line are not significantly different from each other at the 5% level of probability. Error mean squares for weight was 12,387 and for arc sines of percent functional cells was 125.

weight from those in which no embryo was found, so all corpora lutea in the 13-day group were used for the analysis.

All of the groups treated with progesterone for some period during the 25 days had a lower average corpus luteum weight than the 25-day controls. The difference, however, was significant only for the group treated from day-5 to -25 (UTT). Corpora lutea studied at 25 days were from pregnant ewes only. Corpora lutea from non-pregnant ewes which had not returned to heat because of the progesterone injections were almost completely regressed as would be expected. These latter corpora lutea were the only ones of this study which showed any gross evidence of regression. Gross evidences of regression were a marked reduction in size and a decrease in color from a reddish-orange to a light yellow.

The histological study revealed no significant difference in the percentage of "functional" cells, except that there was a significantly lower percentage in the group treated from day-1 to -13. Because of the lack of evidence for histological regression in other groups, the lower percentage of

functional cells in this group was interpreted as a suppression of normal development. This group, and only this group, was subjected to progesterone injections throughout the complete period during which the corpora lutea were developing. Correlations between the functional cells and average corpus luteum weight were calculated. These were quite variable and not significant except for the 25-day control group which had a significant correlation of 0.97.

In no group was there a significant difference in embryo survival, but the groups were not large enough for establishing small differences. The apparent lowering of fertility at 13 days in the UT group was not significant and may be due to chance or possibly to embryos being missed. Further indication that the fertility depression in that group is not real is given by the groups treated similarly to day-13 (UTU, UTT), but with a higher percentage of embryos at day-25. The group in which progesterone injections were made from day-5 to -13 and withdrawn until slaughtered on day-25 (UTU) had no significant decrease in embryo survival compared to controls (75% vs. 80%). This lack of a decrease may be taken as evidence that corpus luteum function was not suppressed to the extent of being incapable of maintaining the pregnancy upon withdrawal of the exogenous progesterone. Furthermore, there were no significant differences between the control and the various 25-day treated groups in respect to embryo weight or crown rump length.

*Discussion*

The progesterone treated groups in every case had lower corpus luteum weights than their respective controls. However, the corpus luteum weight was in no case lower after injections than it was presumed to be at the start of the injection period. This point can be illustrated by comparing the 5-day control weight of 325 mg., with those of the groups in which injections were started at day-5. These weights of 524, 436, and 634 mg. are all greater than the weight of 325 mg. at day-5. Thus, there was some increase in corpus luteum weight during the period of progesterone injections, but the increase was less than in the uninjected controls. There was a greater suppression of this increase by injecting during the early period, day-1 to -5, than during the later periods. A major portion of the increase in corpus luteum weight of the control groups also occurred early in the experimental period. Thus, the period of greatest suppression by progesterone appears to be that period in which the greatest increase in weight occurs normally.

The level of progesterone, presumed to be a high level for reasons previously indicated, appeared to result in a suppression of growth of the corpus luteum but there was no evidence of regression. This is in contrast to the findings in swine (Sammelwitz *et al.*, 1956, 1958; Spies *et al.*, 1958, 1959) in which progesterone caused regression of corpora lutea in pregnant

or hysterectomized gilts to a weight below that at the beginning of injections.

The apparent maintenance of the corpora lutea histologically and functionally in the treated ewes at weights below those of the controls might result from there being two factors controlling the corpus luteum, one factor concerned with corpus luteum growth and development, another concerned with the maintenance of function. The lack of correlation between weight and histological appearance within the treated groups may be a further reflection of the independence of the growth and maintenance factors.

## Summary

Daily injections of 0.4 mg. progesterone per pound body weight were made into bred ewes for various periods of time. The ewes were slaughtered at 5, 13 and 25 days of gestation. The progesterone appeared to cause some suppression of normal corpus luteum growth, but there was no evidence of any regression from initial size during the period of progesterone injection. The greatest suppression of growth and of formation of functional cells occurred when injections were made during part or all of the first 13 days. However, there was no evidence of any lasting effect on the function of these corpora lutea as indicated by the continued maintenance of pregnancy after progesterone injections were terminated. Neither beneficial nor harmful effects on fertility percentage or embryological characteristics could be ascribed to the progesterone injections.

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# EFFECTS OF GRAIN PREPARATION ON PREFERENCES SHOWN BY BEEF CATTLE [1]

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MUCH research has been conducted to determine the value of feeds as measured by chemical analysis, feed efficiency and livestock weight gains. Few investigations have been related to feed preference, particularly as affected by feed preparation.

Pope *et al.* (1958) reported pelleted milo to be less palatable than medium rolled although the grain intake differed only slightly. Brown *et al.* (1952) indicated that ¼-inch pellets were more palatable to dairy cows than ½-inch pellets. Stubbs and Kare (1958) have suggested that the taste reaction of the cow is physiologically different from that of our own. This would question whether the reaction of cattle to different feeds is due to difference in taste recognized by man or some other factor. It would seem desirable to attempt to describe reactions of cattle to feeds in terms of some measure of preference.

The purpose of the present study was to observe differences in preference shown by beef animals for grains as affected by method of feed preparation.

## Experimental

The experiment was designed to evaluate preferences exhibited by beef calves for five different preparations each of corn, milo, and oats when fed as the only grain. The preparations were whole, coarsely ground, finely ground, pelleted and ground pellets. Pellets were made 3/16-inch in diameter, rather than a larger size, to approximate the particle size of whole small grains. Ground pellets were of essentially the same particle size as the finely ground grains. Ground pellets were fed in an effort to separate any effect of the pelleting process from the effect of particle size. Lespedeza hay was fed as the only roughage.

Fifteen purebred Aberdeen-Angus calves with an average weight of 318 lb. were divided by sex and weight into three groups of five. Each group was initially assigned at random to one of the three grains studied. Within each group every individual animal was subsequently assigned to a different preparation of the allotted grain. All calves were fed hay and their assigned grain preparation for a period of one week.

At the end of this period of feeding, preference of grind or form of each grain was observed as exhibited by the calves when each was individually offered simultaneously all five preparations of the grain fed to his group for the past week. This was accomplished by using a feed bunk

[1] Published with the approval of the director of the Arkansas Agricultural Experiment Station.

divided into five equal compartments. Each compartment was fitted with an easily removable feed box which facilitated emptying and weighing back uneaten grain yet prevented spillage.

Four pounds of each preparation of the grain were offered. The calf was allowed to eat free-choice any or all of the five preparations for a time up to 30 min. or until eating stopped. Each animal was under constant observation during the free-choice period. A record was obtained of the minutes spent eating each preparation and the number of times changes from one preparation to another occurred. The amount of each preparation remaining in the feed box after the calf had stopped eating was weighed and pounds consumed recorded. In this manner one could determine if there was a tendency for calves to select the preparation they had been eating the previous week or if they were actually selective as to form or preparation of grain consumed.

The five calves receiving corn were individually observed on Monday afternoon at 4. Calves fed milo were observed the following afternoon and those fed oats the second day following. When all five calves being fed each grain had been observed during the free-choice period, each calf of the group was shifted to another preparation for the next week. At the end of the second week all five preparations were again simultaneously offered each calf for free-choice selection under observation. This procedure was followed for 5 weeks. At the end of this time each calf had eaten for one week each of the preparations of the initially assigned grain and five records of observations of preference obtained for each calf.

After the first 5 weeks the grains were rotated among the groups of calves and the procedure repeated. This was done for three 5-week periods. Thus at some time during the study each of the 15 calves had been fed each form or preparation of all three of the grains, and 15 observations had been made of free-choice selections of each calf. Data from these observations were analyzed by the chi-square and analysis of variance procedures according to Snedecor (1956).

A preliminary free-choice trial for each group was conducted before the animals had been fed the experimental rations. It was felt this trial should be free of bias in preference related to previous feeding which might cause calves to make certain selections because of being accustomed to a particular form of grain.

The grains and preparations were rated on the basis of pounds consumed, minutes spent eating each form, and choice. Ratings on choice were determined on a numerical point basis. A preparation selected first by the calf received three points, second two, and third one point. The preparation having the highest point total was considered first choice of the calves. The first preparation which a calf ate for 15 seconds or more was considered first choice. Fifteen seconds eating time was arbitrarily chosen as the minimum time required for a calf to indicate a definite

choice. Less than 15 seconds eating time was thought to be merely sampling and rejection.

## Results and Discussion

*Preliminary Trial.* During the preliminary trial the calves showed a preference for whole oats over all other preparations of this grain as measured by pounds consumed, time spent eating each form and choice rating. Finely ground and pelleted oats were less favorably received by the calves, ground pellets ranking last by all measures of preference as shown in table 1. Whole milo was most preferred as indicated by pounds consumed and time spent eating; however, coarsely ground milo ranked first by choice and whole milo second. Finely ground milo and ground milo pellets were refused most consistently. Calves assigned to corn reacted

TABLE 1. PREFERENCES OF GRAINS BY CALVES AS AFFECTED BY PREPARATION—PRELIMINARY TRIAL [a]

| | Corn [b] | | | | | Milo | | | | | Oats | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | W | C | F | P | GP | W | C | F | P | GP | W | C | F | P | GP |
| Consumption: | | | | | | | | | | | | | | | |
| Total pounds | 0.6 | 9.9 | 8.6 | 1.2 | 1.1 | 10.5 | 2.4 | 0.5 | 2.7 | 0.7 | 8.0 | 7.6 | 2.7 | 2.1 | 1.0 |
| Percent of total | 3.0 | 46.0 | 40.0 | 6.0 | 5.0 | 63.0 | 14.0 | 3.0 | 16.0 | 4.0 | 37.0 | 35.0 | 13.0 | 10.0 | 5.0 |
| Time spent eating: | | | | | | | | | | | | | | | |
| Total minutes | 2.0 | 35.0 | 40.0 | 7.0 | 3.0 | 37.0 | 15.0 | 1.0 | 4.0 | 4.0 | 24.0 | 22.0 | 10.0 | 11.0 | 2.0 |
| Minutes per lb. | 3.3 | 3.5 | 4.6 | 5.8 | 2.7 | 3.5 | 6.2 | 2.0 | 1.5 | 5.7 | 3.0 | 2.9 | 3.7 | 5.2 | 2.0 |
| Choice rating: | 2 | 1 | 3 | 4 | 5 | 2 | 1 | 4 | 3 | 5 | 1 | 3 | 2 | 4 | 5 |

[a] Each entry represents data from five calves.
[b] Abbreviations: W—whole; C—coarse; F—fine; P—pellets; GP—ground pellets.

somewhat differently from those fed oats or milo in that whole corn was refused as were pellets and ground pellets. Coarse and finely ground forms of corn were consumed in greatest quantity.

When data from all grains were pooled and preparations were the only consideration all three measures of preference were in agreement and the forms ranked as follows: Coarse, whole, fine, pellets and ground pellets. The calves consumed 21.4 lb. of both corn and oats and 16.8 lb. of milo while under observation during the preliminary trial.

*Complete Trial.* These data include 15 separate free-choice observations for each calf for a total of 225 observations. Results are summarized in table 2 with analysis of variance based on consumption presented in table 3. Differences in consumption due to calves and grains were not significant; however, there were highly significant differences due to preparations. Consumption was greater ($P<.01$) for whole and ground grains than for pelleted or ground pellet forms. Finely ground preparations were consumed in less quantity ($P<.01$) than whole or coarsely ground forms. This was particularly apparent with oats and milo. These latter two forms

TABLE 2. PREFERENCE OF GRAINS AS AFFECTED BY PREPARATION[a]

| Item | Corn[b] | | | | | Milo | | | | | Oats | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W | C | F | P | GP | W | C | F | P | GP | W | C | F | P | GP |
| Consumption: | | | | | | | | | | | | | | | |
| Total pounds | 139 | 145 | 140 | 93 | 37 | 171 | 131 | 61 | 144 | 55 | 186 | 176 | 98 | 88 | 27 |
| Percent of total | 25 | 26 | 25 | 17 | 7 | 30 | 23 | 11 | 26 | 10 | 32 | 31 | 17 | 15 | 5 |
| Time spent eating: | | | | | | | | | | | | | | | |
| Total minutes | 355 | 466 | 472 | 273 | 130 | 411 | 473 | 182 | 451 | 172 | 445 | 512 | 352 | 298 | 90 |
| Minutes per lb. | 2.6 | 3.2 | 3.4 | 2.9 | 3.5 | 2.4 | 3.6 | 3.0 | 3.1 | 3.1 | 2.4 | 2.9 | 3.6 | 3.4 | 3.3 |
| Choice rating: | 1 | 3 | 4 | 2 | 5 | 2 | 3 | 5 | 1 | 4 | 1 | 2 | 4 | 3 | 5 |

[a] Each entry represents data from 15 calves and 5 replications for each calf.
[b] Abbreviations: W—whole; C—coarse; F—fine; P—pellets; GP—ground pellets.

represented 63, 53 and 51% of the total pounds consumed of oats, milo and corn, respectively. Whole milo and oats were consumed in largest quantity whereas coarsely ground corn ranked first by consumption. This is in agreement with data obtained during the preliminary trial. Consumption of whole corn much more nearly approached the ground forms during the complete trial than during the preliminary trial, indicating that perhaps calves do not eat whole corn readily until becoming accustomed to it. The consumption pattern for oats was the same for both the preliminary and complete trials thus indicating that initial selections of forms of oats reflected true preference—although having been forced to consume other forms when subsequently given a free-choice, the preferences were not altered. Pellets were consumed in greater amounts ($P<.01$) than ground pellets.

The significant interaction observed between grain and preparation varied for the different grains; however, there was no indication of this in the

TABLE 3. ANALYSIS OF VARIANCE BASED ON CONSUMPTION

| Source of variation | D/F | M.S. |
|---|---|---|
| Total | 224 | |
| Treatment[a] | 14 | 174.74** |
| Grain | 2 | 1.40 |
| C vs. M–O | 1 | 1.88 |
| M vs. O | 1 | .91 |
| Preparation | 4 | 478.75** |
| W–C–F vs. P–GP | 2 | 497.68** |
| F vs. W–C | 1 | 450.86** |
| P vs. GP | 1 | 468.77** |
| Grain x Preparation | 8 | 66.07** |
| Calves | 14 | 13.04 |
| Error | 196 | 15.10 |

** Significant at the 1% level of probability.
[a] Abbreviations: C—corn; M—milo; O—oats; W—whole; C—coarse; F—fine; P—pellets; GP—ground pellets.

chi-square analysis based on first choice. There is reason to expect that significance would be observed more often than normal in the analysis of variance of consumption because the error term contains differences among several observations on the same calf as well as observation differences among calves.

The choice rating indicated that the preferences of the calves were consistently in favor of the coarser preparations. Finely ground grains and ground pellets ranked last by choice for all three grains. Pellets received the highest choice rating for milo; however, they ranked second for corn and third for oats, which indicates that pelleting milo improves its desirability more than does pelleting grains such as corn and oats. Ground pellets were last by choice. From these results, it was assumed that the greater preference resulting from pelleting was affected more by particle size than by any other change. The calves remained on their first choice preparation 2 minutes or less over 50% of the time, which was an indication that form played an important part in selectivity. Oats pellets were selected as first choice before the finely ground forms; however, fewer minutes were spent eating oat pellets and fewer pounds consumed than finely ground oats. This points to the fact that factors associated with the oat pellets caused the animals to reject them even after indicating a choice preference for the larger particle size.

The effects of preparation on first choice rating were shown by means of the chi-square analysis to be no different for the three grains studied. Differences between preparations were highly significant ($P<.01$).

## Summary

Fifteen Aberdeen-Angus calves weighing 298 to 353 lb. were fed for 105 days to determine preferences for five different preparations each of corn, milo and oats. The preparations were whole, coarsely ground, finely ground, pellets and ground pellets.

Calves offered more than one grain preparation were selective in their choice. Over 50% of the time the calves remained on their first choice preparation 2 minutes or less before sampling another.

First choice preferences indicated differences between preparations but not between grains. Highly significant differences were observed in consumption due to preparation. Finely ground grains were consumed in smaller quantity ($P<.01$) than whole or coarsely ground preparations. Pellets were more preferable ($P<.01$) than ground pellets.

Ground pellets and finely ground grains were seldom given a first choice rating by the calves and were generally consumed in smaller amounts.

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# RELATIONSHIP BETWEEN THE CONCENTRATIONS OF CRUDE PROTEIN AND APPARENTLY DIGESTIBLE PROTEIN IN FORAGES

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IN 1869 Stohmann reported that the apparent digestibility of protein increases as the concentration of protein in the ration increases and he devised an equation relating these variables. Interest in this relationship appears to have lain dormant until 1926 when Mitchell provided supporting data. Later Mitchell (1942), in a statistical study of the data tabulated by Morrison (1936), found that the following equation expressed the curvilinear relationship between the apparent digestibility (Y) of protein and the percentage of protein (X) in the forages: $Y=42.64\ (X-5)^{0.215}$. In a study of data obtained at the Kentucky station and of data recorded in Schneider's tables (1947) both of which were obtained with sheep and cattle, Forbes (1950) computed the "a" and "b" constants of the general equation, $Y=a(X-5)^b$, to be: 40.96 and 0.226; 40.31 and 0.218, respectively. For data obtained with cattle the "b" values were 0.287 and 0.272 and those obtained with sheep were 0.210 and 0.200 for the Kentucky and Schneider data, respectively. These data suggest that the protein in low-protein forages is more efficiently digested by sheep than by cattle. For green forages hand fed to, and grazed by, cattle, Reid (1952) derived "b" values of 0.290 and 0.288, respectively, for the equation of the form used by Mitchell. However, it was found that the following equation provided a better fit to the data: $Y=156.47\ \log X-2.537X-75.99$; where, Y=apparent digestibility of protein (%) and X = crude protein in forage. The relationship of apparent digestibility (Y) to the crude protein concentration (X) of forages has been expressed by equations of still other forms: $Y=69.7\ \log X-13.9$ (Glover *et al.*, 1957) and $Y=49.08+1.382X$ (McDonald and Purves, 1957).

In a study of data obtained with green forages fed to steers in an attempt to derive a more direct estimate of the indigestible protein concentration of forages which might be used as a digestibility indicator, Reid (1952) observed a relationship of high predictive value between the percentages of apparently digestible protein (Y) and crude protein (X) in forage dry matter: $Y=0.946X-3.52$. The standard error of estimate was 0.32% digestible protein which is equivalent to a mean error of only 2.85% for this population. Similarly high correlations (r=0.98 to 0.99) between the percentages of digestible and crude protein in forages and essentially the

[1] Part of the data reported here were taken from the thesis presented by J. A. Holter to the Graduate School, Cornell University, in partial fulfillment of the requirements for the Doctor of Philosophy degree.

same regression equation was reported by others (Dijkstra, 1954, 1955; Dijkstra and Brandsma, 1955; Glover *et al.*, 1957).

The objectives of this study were to examine the relationships between the apparent digestibility of protein and the concentration of crude protein in forages of different kinds and to determine the accuracy with which the digestible protein value can be predicted from the concentration of crude protein.

## Materials and Methods

Two sources of data were employed in these studies; one source consisted of the data obtained in experiments conducted by the authors (hereafter called "Cornell data") and the other source is the data recorded in the Morrison tables (1956).

*Cornell Data.* The first source of data employed in these studies was obtained in conventional digestion trials conducted during an 8-year period involving 27 fresh, green forages and 26 hays fed to cattle and 26 hays fed to sheep. Represented among the forages were single-species stands of alfalfa, Ladino clover, timothy, Birdsfoot trefoil, red clover, bromegrass, Kentucky bluegrass, orchard grass, almost pure quackgrass, and mixtures of these and other plants. Each of the first-growth forages was harvested at two to five growth stages between May 18 and July 20 and the aftermath forages were cut during the period of July to September. As a consequence, the forages represented a wide range of botanical and chemical composition and of physical characteristics.

In the digestion trials, 3 to 12 steers and/or 2 to 6 wethers were employed. The fecal collection periods in the trials with fresh, green forage fed in two or four meals per day were of 4- to 10-day duration and in the trials with hays fed in two meals per day the collection periods were 7 to 14 days long. Preliminary feeding periods of 10 to 26 days were employed.

*Morrison Data.* A study was made also of the data recorded in the Morrison tables (1956). Certain of the Morrison data were not included in this study because the forages represented were found to belong to a population different from that of the forages included with respect to the relationship under study. The data which were excluded represented forages containing grain or high-protein seeds, brown and weathered hays, silages containing grains or preservatives having nutritive value, and lespedezas. No adequate explanation has been provided for the peculiarly low digestibility of protein in lespedeza (Hawkins, 1955). The Morrison data studied included those obtained for 101 green forages, 124 hays and 28 silages. Each of the values for most of the forage categories is an average obtained in numerous digestion trials. The Morrison data represent experiments with both sheep and cattle.

Other than differences inherent in the sources, the major difference be-

tween the two sets of data is the basis on which the protein concentration is expressed. In the Cornell data the protein concentration is on the dry basis, whereas in the Morrison data it is expressed on the organic matter basis. The data from both sources were examined in correlation and regression analyses.

The relationships derived in this study were applied to data obtained in digestion experiments with several non-legumes fertilized with nitrogen at various levels of application and to data obtained in experiments dealing with the leaf and stem fractions of alfalfa forage.

TABLE 1. AVERAGE AND RANGE OF THE CONCENTRATION AND APPARENT DIGESTIBILITY OF PROTEIN IN THE FORAGES OF THE TWO SOURCES OF DATA STUDIED

| Kind of forages | Animal | No. of forages | Crude protein | | | |
|---|---|---|---|---|---|---|
| | | | Concentration [c] | | Apparent digestibility [d] | |
| | | | Average | Range | Average | Range |
| **Cornell data** | | | | | | |
| Green | C[a] | 27 | 15.91 | 6.79 to 26.70 | 68.8 | 35.5 to 82.5 |
| Hay | C | 26 | 11.66 | 7.28 to 17.12 | 59.2 | 37.6 to 73.8 |
| Hay | S[b] | 26 | 13.36 | 6.69 to 23.61 | 64.6 | 47.7 to 76.8 |
| **Morrison data** | | | | | | |
| Green | C & S | 101 | 14.33 | 3.23 to 29.01 | 64.1 | 24.0 to 85.0 |
| Dry | C & S | 124 | 12.61 | 2.59 to 24.67 | 55.3 | 8.0 to 79.0 |
| Silage | C & S | 28 | 13.79 | 5.31 to 22.01 | 58.9 | 29.0 to 76.0 |

[a] C represents cattle.
[b] S represents sheep.
[c] Concentration expressed as a percentage of the dry matter for the Cornell data and of the organic matter for the Morrison data.
[d] Apparent digestibility expressed as a percentage.

## Results and Discussion

Table 1 summarizes the average and range of the crude protein concentration and the apparent digestibility of protein in forages of various kinds fed to cattle and/or sheep in the experiments from which the two sources of data were derived.

*Apparent Digestibility of Protein.* The intra-forage (*i.e.* inter-animal) coefficient of variation in digestibility of protein for the Cornell data was 2.4%. As indicated by the coefficients in table 2, the apparent digestibility of protein is highly significantly correlated with the concentration of crude protein in forages. The relationships between these two variables for green and dry forages were found to deviate highly significantly from linearity. On the other hand, the regression for silages was essentially linear, an observation made also by McDonald and Purves (1957). For green and dry forages the curvilinearity of the relationship is the result of the decrease in the relative contribution of metabolic nitrogen to the total fecal nitrogen as the crude protein concentration of forages increases. This effect will be discussed in more detail later in this report.

Fitting an equation of the form proposed by Mitchell (1942) to the data for the Cornell green forages fed to cattle resulted in the following expression: $Y=34.90\ (X-5)^{0.297}$, where Y = apparent digestibility of protein (%) and X = crude protein content (%). Essentially the same equations were computed by Forbes (1950) from his own data [$Y=35.40\ (X-5)^{0.287}$] and from Schneider's data [$Y=35.31\ (X-5)^{0.272}$], for forages fed to cattle.

It was observed in the Cornell green-forage data that the percentage of apparently indigestible protein varied from 3.61 to 5.24. The constant, 5, in the parenthetical term, (X—5), of Mitchell's equation is an empirical value intended to estimate the percentage units of fecal protein (Mitchell,

TABLE 2. RELATIONSHIP BETWEEN THE PERCENTAGE OF CRUDE PROTEIN (X) AND THE PERCENTAGE APPARENT DIGESTIBILITY OF PROTEIN (Y)

| Kind of forage | Animal | No. of forages | Correlation coefficient | Regression equation | Standard deviation from regression |
|---|---|---|---|---|---|
| | | | Cornell data | | |
| Green | C[a] | 27 | 0.96 | $Y=155.4\log X-2.77X-69.7$ | 3.3 |
| Hay | C | 26 | 0.90 | $Y=136.7\log X-2.34X-58.0$ | 3.6 |
| Hay | S[b] | 26 | 0.95 | $Y=104.8\log X-1.85X-25.6$ | 2.9 |
| | | | Morrison data | | |
| Green | C & S | 101 | 0.86 | $Y=89.5\log X-1.23X-16.6$ | 8.1 |
| Dry | C & S | 124 | 0.92 | $Y=82.4\log X-0.21X-28.8$ | 7.8 |
| Silage | C & S | 28 | 0.75 | $Y=16.1\log X-1.13X-25.4$ | 7.6 |

[a] C represents cattle.
[b] S represents sheep.

1954). As a consequence of requiring the deduction of a constant amount (5%) of indigestible protein, the equation of the form, $Y=a(X-5)^b$, did not fit, as closely as desired, the data obtained in this study. A study of other types of equations showed that equations of the general form, $Y=a+bX+c\log X$, provided an excellent fit to the data for all classes of forage included in this study.

In table 2 are summarized the equations derived for the various categories of forages. These data suggest that the digestibility of protein per unit of crude protein is slightly higher for green forages than for hays. Although the difference between the regression equations for these two classes of forages approaches mathematical significance (P=0.06), the difference is essentially biologically inconsequential. The small, though consistent, difference in the digestibility of the protein of green and dry forages might be attributable to chemical changes in protein effected by preservation treatments, the physical nature of forages and its effect upon

the excretion of metabolic nitrogen, and, in the case of hays, leaf loss resulting in relatively less protein and more fiber.

Since the protein concentration is not expressed on the same basis for the Cornell and Morrison data, the regressions obtained for the two sources of data are not comparable. Nevertheless, with an allowance for the difference in the basis of expression, the relationships obtained are remarkably similar despite the fact that a great variety of materials such as small-grain straws are included in the Morrison data.

The Cornell data were examined to determine whether sheep are different from cattle with respect to the protein digestibility-protein concentration relationship. It was found that the regressions for the green forages and hays fed to cattle were significantly different ($P<0.05$) from that for hays fed to sheep. As suggested by Forbes (1950), sheep digest the protein of low-protein forages more efficiently, and that of high-protein forages less efficiently than do cattle. Whether this is the result of a smaller excretion by sheep of metabolic fecal nitrogen per unit of dry matter consumed, remains to be determined. The possible explanation exists that, under the usual conditions of digestion trials, sheep may consume less feed (particularly of low-protein, high-fiber feeds) per unit of weight and, therefore, excrete less nitrogen of metabolic origin than do cattle. The effect of a lower metabolic excretion of nitrogen in contributing to a higher apparent digestibility of protein would be very pronounced at low levels of protein intake because under this condition metabolic nitrogen constitutes most of the total nitrogen of the feces.

*Relationship of Crude Protein to Digestible Protein.* Since protein is rationed to ruminants on the basis of apparently digestible protein and since it would appear that the "indigestible" protein fraction of forages might be adapted for use as a digestibility indicator, a study was made of the relationships between the percentages of crude and digestible protein in the forages represented by the two sources (Cornell and Morrison) of data. As shown in table 3, highly significant correlations between these two variables ranging from 0.975 to 0.997 were found for the six classes of forages studied. The equation relating these two variables was found to have a high prediction value in each instance. While the regression coefficients obtained in the study of the Cornell data were not significantly different ($P<0.01$), the intercept values (a) for hays fed to sheep and hays fed to cattle were significantly different when adjusted to a common regression.

In the Morrison data, the regression coefficients for green and dry forages were statistically similar, but the intercept values (a) adjusted to a common regression were statistically different. This further demonstrates that the apparent digestibility of protein per unit of crude protein is slightly higher in green forages than in dry forages.

Direct comparisons of the Cornell and Morrison data were not possible since the percentage of crude protein in the two sets of data is expressed

on the dry basis and organic matter basis, respectively. Although certain of the intercept values were significantly different from others, the difference in the digestible protein values predicted by the equations within the Cornell data or the Morrison data was not biologically significant. Therefore, the data were pooled to compute a common regression equation for the three classes of forages within each source of data. As the standard deviations from regression indicate (table 3) the data conform very closely to the equations fitted to the data when crude protein is expressed on both the dry basis (Cornell data) and the organic matter basis (Morrison data). The individual observations of these two sources are plotted

TABLE 3. RELATIONSHIP BETWEEN THE PERCENTAGES OF CRUDE PROTEIN (X) AND APPARENTLY DIGESTIBLE PROTEIN (Y) IN FORAGES

| Kind of forage | Animal | No. of forages | Correlation coefficient | Regression | Standard deviation from regression |
|---|---|---|---|---|---|
| | | | Cornell data | | |
| Green | C[a] | 27 | 0.997 | Y=0.948X—3.60 | 0.37 |
| Hay | C | 26 | 0.989 | Y=0.919X—3.62 | 0.36 |
| Hay | S[b] | 26 | 0.995 | Y=0.867X—2.56 | 0.42 |
| All | C & S | 79 | 0.995 | Y=0.929X—3.48 | 0.46 |
| | | | Morrison data | | |
| Green | C & S | 101 | 0.991 | Y=0.881X—2.61 | 0.80 |
| Dry | C & S | 124 | 0.992 | Y=0.883X—3.29 | 0.65 |
| Silage | C & S | 28 | 0.975 | Y=0.798X—2.53 | 0.86 |
| All | C & S | 253 | 0.988 | Y=0.883X—3.07 | 0.83 |

[a] C represents cattle.
[b] S represents sheep.

in figures 1 and 2, respectively. It would appear that the slightly lower regression coefficients for the Morrison data are attributable to a higher proportion of the Morrison data than of the Cornell data having been derived from experiments with sheep.

In view of the heterogenous nature of the forages involved in this study, it is obvious that the crude protein concentration-digestible protein relationship is practically invariant with plant species, growth stage of forage, and the form (i.e. green forage, hay, silage) in which the forage is fed.

The curvilinearity of the relationship between the percentage of crude protein and the apparent digestibility of protein and the rectilinearity of the relationship between the percentages of crude and apparently digestible protein in forages seem to be the result of certain interrelationships among the components of forages and the excretion of metabolic fecal nitrogen. For example, the concentration of protein and the cell-wall constituents of forages are inversely correlated. Also, the excretion of metabolic fecal nitrogen and the concentration of crude fiber are positively correlated (Mitchell,

1934; Meyer, 1956). These and possibly other compositional interrelationships contrive to result in a relatively constant reduction in the proportion of the total fecal nitrogen contributed by metabolic nitrogen as the nitrogen concentration of forages increases. The constancy of these interrelationships is demonstrated by the Cornell data in which the predicted digestible protein values were different from the measured values by more than 0.6 per-

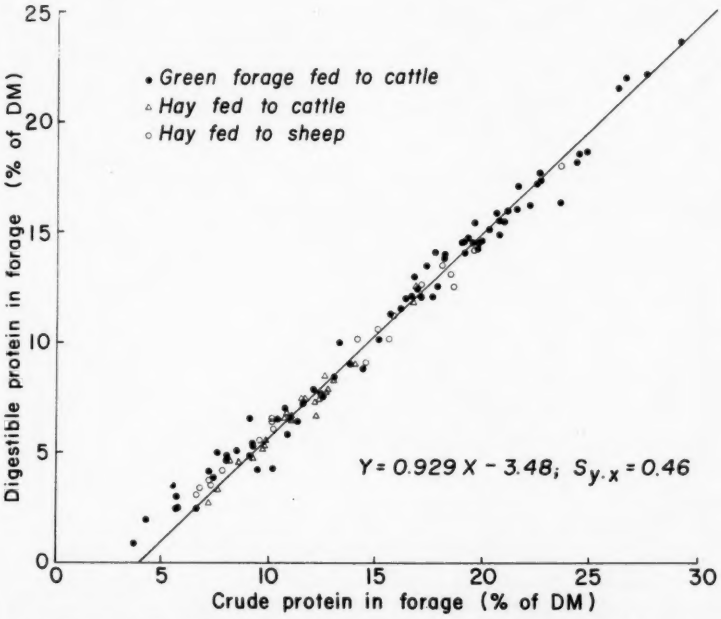


**Figure 1. The relationship between the crude and digestible protein concentrations of forages (Cornell data).**

centage units for only four of the 79 forages studied and none of these was in error by as much as 0.9 percentage unit. It seems reasonable to conclude from these studies that the true digestibility of protein is relatively constant regardless of the protein content of forages.

*Effect of Nitrogen Fertilization of Grasses upon the Crude-Digestible Protein Relationship.* Greenhill (1936) and Ferguson and Terry (1954) showed that the proportion of the total nitrogen constituted by non-protein nitrogen is greater in forages highly fertilized with nitrogen than in those grown under conditions of low-nitrogen fertilization. Since this finding suggests that the relative amount of true protein is less in forages liberally fertilized with nitrogen than in those grown on low-nitrogen soils, a study was made of the relationship between the crude- and digestible-protein

concentrations of four non-legumes fertilized with various amounts of nitrogen. As the data in table 4 show, the equation, Digestible protein (%)=0.929 crude protein (%)—3.48, derived from the Cornell data representing all of the forages studied with sheep and cattle, predicted quite accurately the percentage of digestible protein even in forages grown

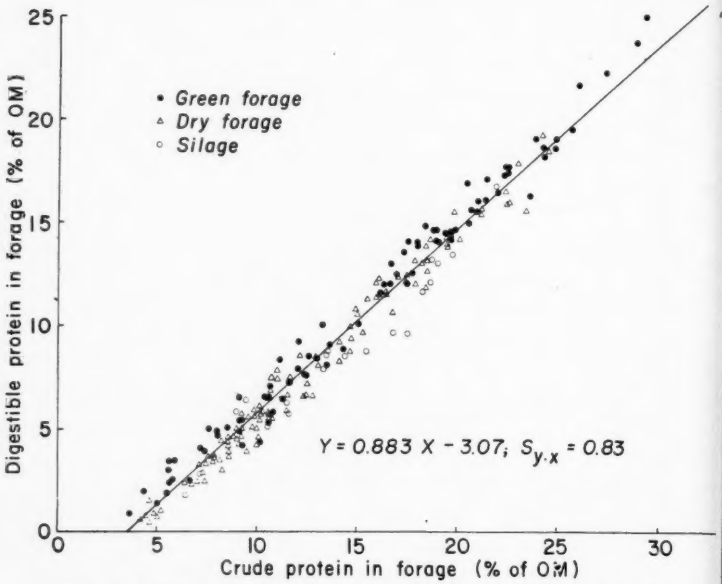


**Figure 2. The relationship between the crude and digestible protein concentrations of forages (Morrison data).**

under conditions of high-nitrogen fertilization. Disregarding the bromegrass sample having only 4.6% crude protein, the digestible protein values of these forages was estimated with an average error of only 2%. The forages included in this study were of a population different from that which was employed to derive the crude protein-digestible protein relationship described earlier in this report.

*Relationship of Crude Protein to Digestible Protein in the Leaves and Stems of Alfalfa.* The data from which the relationship between crude and digestible protein was derived in this study were obtained in digestion experiments in which the whole, harvestable plant was fed. Therefore, it was desirable to determine whether parts (leaves and stems) of plants conform to the relationship. This was examined using alfalfa from two sources, each of which was harvested at two growth stages. These data (table 5) indicate that the generalized equation developed from the

TABLE 4. ACCURACY OF THE ESTIMATED DIGESTIBLE PROTEIN CONTENT OF GRASSES FERTILIZED WITH VARIOUS AMOUNTS OF NITROGEN

| Nitrogen fertilization | Crude protein | Digestible protein | |
|---|---|---|---|
| | | Measured[a] | Estimated[b] |
| (lb./acre) | (Percent of dry matter) | | |
| | Reef Canary grass fed to wethers[c] | | |
| 0 | 14.0 | 9.6 | 9.5 |
| 100 | 16.4 | 11.6 | 11.8 |
| 200 | 22.9 | 17.8 | 17.8 |
| | Brome grass fed to heifers[d] | | |
| 25 | 7.5 | 4.6 | 3.5 |
| 125 | 12.4 | 8.3 | 8.1 |
| 225 | 17.2 | 12.8 | 12.5 |
| | Orchard grass fed to wethers[e] | | |
| 100 | 13.9 | 9.4 | 9.4 |
| 200 | 17.5 | 12.9 | 12.8 |
| 400 | 18.0 | 13.3 | 13.3 |
| | Timothy fed to wethers[f] | | |
| 0 | 19.6 | 14.3 | 14.8 |
| 150 | 23.6 | 18.1 | 18.4 |

[a] Values determined in conventional digestion trial.
[b] Values predicted by use of equation: Digestible protein (%)=0.929 crude protein (%)—3.48.
[c] Data reported by Barth (1958).
[d] Data reported by Markley, Cason, and Baumgardt (1957).
[e] Data reported by Poulton, Macdonald, and VanderNoot (1957).
[f] Data obtained in authors' experiments.

TABLE 5. ACCURACY OF THE ESTIMATED DIGESTIBLE PROTEIN CONTENT OF ALFALFA LEAVES AND STEMS

| Cutting time | Fraction of plant | Crude protein | Digestible protein | |
|---|---|---|---|---|
| | | | Measured[a] | Estimated[b] |
| | | (Percent of dry matter) | | |
| Source 1 | | | | |
| Early | Leaf | 30.0 | 25.0 | 24.4 |
| | Stem | 17.3 | 13.3 | 12.6 |
| Late | Leaf | 32.3 | 26.8 | 26.6 |
| | Stem | 16.2 | 12.5 | 11.6 |
| Source 2 | | | | |
| Early | Leaf | 26.0 | 19.5 | 20.1 |
| | Stem | 12.8 | 8.8 | 8.4 |
| Late | Leaf | 21.8 | 16.8 | 16.8 |
| | Stem | 10.4 | 5.4 | 6.1 |

[a] Values determined in conventional digestion trial with wethers.
[b] Values predicted by use of equation: Digestible protein (%)=0.929 crude protein (%)—3.48.

Cornell data allows the digestible protein value of leaf and stem fractions to be predicted with a high degree of accuracy. This finding gives further support to the view that the peculiar interrelationships among the constituents of forage crops ensure a relatively uniform reduction in the contribution of metabolic nitrogen to the total nitrogen of the feces as the percentage of crude protein in forages increases.

## Summary

A study was made of the relationship between the concentration and digestibility of crude protein in forages representing a wide range of plant species, growth stages, preservation treatments, and sources of data.

The digestibility of protein increases exponentially as the concentration of crude protein in forages increases. On the other hand, the percentage of digestible protein (Y) increases rectilinearly as that of crude protein (X) increases, and the relationship is expressed by the equation, $Y = 0.929X - 3.48$, for which the standard error of estimate was found to be 0.46%. It would appear that interrelationships exist among the constituents of forages which result in the excretion of metabolic nitrogen in a manner correlated with the crude protein concentration of forages. Thus, the true digestibility of protein is relatively constant regardless of the concentration of crude protein in forages.

The relationship between the concentrations of crude and digestible protein in the leaves and stems of alfalfa and in grasses fertilized with high levels of nitrogen conformed closely to that derived from the study of a variety of other forages.

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# EFFECT OF SACCHARIN ON CONSUMPTION OF STARTER RATIONS BY BABY PIGS [1, 2]

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PALATABILITY of a product usually refers to its acceptability by an animal or man. The development of reliable palatability tests for the pig is more difficult than that for man where taste panels are used with a fair degree of reliability. The pig's free-choice selection, hereafter referred to as preference, has been used by several workers as a criterion in comparing the relative palatability of various feedstuffs, additives or rations offered simultaneously.

In preference studies Lewis *et al.* (1955) have shown that when two or more pig starter rations are offered, early weaned (1 to 2 weeks of age) baby pigs select rations containing sucrose. Jensen *et al.* (1955) conducted preference studies in which nursing pigs were offered choices of different levels of sugar and 0.05% saccharin. The pigs consumed nine times more of the 20% sugar ration than of the saccharin ration. Hanson *et al.* (1954) conducted three preference trials with three-week-old pigs in which rations containing no sugar, 10% sugar and a saccharin level equivalent to 10% sugar in sweetness were fed. The pigs consumed a predominance of the ration containing 10% sugar.

The purposes of the experiments reported herein were (1) to develop reliable palatability evaluation techniques and (2) to determine if the addition of saccharin at various levels influences the choice and consumption of practical rations offered in the form of meal, pellets and crumbles.

## Experimental

Crossbred pigs from the mating of Farmers Hybrid Boars to Poland China x Landrace x Duroc sows were housed in concrete-floored pens provided with heat lamps. The pigs were self-fed, and automatic founts provided fresh water. They were given iron pills at 3 days of age and at the beginning of the experiment to prevent anemia and were vaccinated with cholera and erysipelas serum at 5 days of age. Pig weight and feed consumption data were recorded weekly.

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[2] This research was partially supported by grants-in-aid and materials from Monsanto Chemical Co., St. Louis, Mo.; Merck, Sharp and Dohme Research Laboratories, Rahway, New Jersey; and, Cudahy Laboratories, Omaha, Nebraska.
[3] Present address: Yoder Feeds, Inc., Kalona, Iowa.
[4] The authors acknowledge Donald Quinn, Research Farm Superintendent and associates for their assistance in conducting the experiments.
[5] Department of Animal Husbandry.

TABLE 1. EXPERIMENTAL PROCEDURE

| Item | Experiment number | | |
|---|---|---|---|
| | I | II | III |
| Total pigs, no. | 36 | 96 | 54 |
| Replicates, no. | 3 | 8 | 3 |
| Pigs per lot, no. | 4 | 4 | 3 |
| Av. initial age, days | 16.0 | 14.6 | 17.4 |
| Av. initial wt., lb. | 8.4 | 8.3 | 7.8 |
| Time on experiment, wk. | 5 | 4 | 4 |

The 186 pigs were allotted at random from outcome groups of initial weight within replication. The experimental procedures followed for the different experiments are shown in table 1.

In experiments I and II, five feeders each with a different level of saccharin (0, ⅛, ¼, ½ and 1 lb./ton) were placed in each pen (figure 1). Three different forms of the ration were fed, namely, meal, pellets, and crumbles; however, only one form was offered to each pen. In experiment III only two self-feeders were placed in each pen. The two rations offered free-choice in each pen made up one of the six possible combinations of the four levels of saccharin (0, ¼; 0, ½; 0, 1; ¼, ½; ¼, 1; ½, 1 lb./ton). Only the pelleted rations were used in this experiment. The individual self-feeder was considered as the experimental unit in these experiments. All feeders were randomly rearranged twice weekly and the feed in the trough

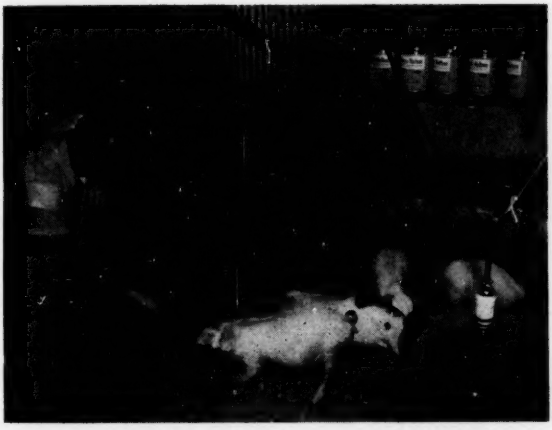

**Figure 1. Experiment I. Arrangement of feeders showing waste feed collection platforms and containers on ledge for collecting discard feed.**

TABLE 2. COMPOSITION OF STARTER RATIONS

| Ingredients | Experiment number | |
|---|---|---|
| | I | II and III |
| | % | % |
| Ground yellow corn | 32.40 | 41.05 |
| Oat groats | 20.00 | 20.00 |
| Solv. soybean oil meal (50% protein) | 21.90 | 22.80 |
| Dried whey (70% lactose) | 20.00 | 10.00 |
| Fish solubles | 2.50 | 2.50 |
| Calcium carbonate (35% Ca) | 0.75 | 0.75 |
| Dicalcium phosphate (26% Ca, 18% P) | 1.30 | 1.55 |
| Iodized salt | 0.20 | 0.40 |
| Trace mineral mix [a] | 0.20 | 0.20 |
| Vitamin-antibiotic premix [b] | 0.50 | 0.50 |
| Pepsin (1:3000) | 0.25 | 0.25 |

[a] Supplied the following in p.p.m.: Fe, 140.8; Cu, 9.6; Co, 3.2; Zn, 163.2 and Mn, 113.6.
[b] Supplied sufficient quantities of the following to bring the calculated analysis per lb. of ration to: Vitamin A, 3000 I.U.; vitamin $D_2$, 500 I.U.; riboflavin, 4.0 mg.; pantothenic acid, 8.0 mg.; niacin, 25.0 mg.; choline, 584 mg.; vitamin $B_{12}$, 20 mcg.; folic acid, 0.5 mg.; chlortetracycline, 40 mg.; 3-nitro-4-hydroxyphenylarsonic acid, 11.35 mg.

of the self-feeder was removed and recorded to prevent the accumulation of stale feed.

The composition of the basal pig-starter ration is shown in table 2. The ration was composed of ingredients commonly used commercially in baby pig feeds. Gluside insoluble saccharin [6] was used in experiment I, whereas a more soluble form of saccharin (gluside soluble [7]) was used in experiments II and III.

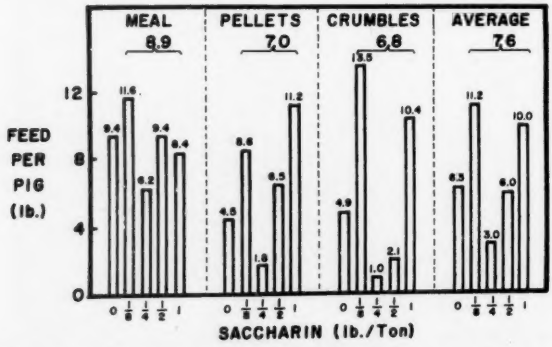


**Figure 2. Experiment I. Effect of insoluble saccharin on starter consumption by early weaned baby pigs.**

[6] Supplied by Merck, Sharp and Dohme Research Laboratories, Rahway, N. J.
[7] Supplied by Monsanto Chemical Co., St. Louis, Mo.

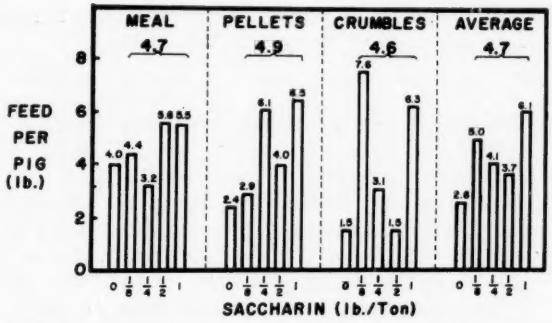


Figure 3. Experiment II. Effect of soluble saccharin on starter consumption by early weaned baby pigs.

## Results

The results presented in figures 2 and 3 show that in each of experiments I and II the pigs preferred some level of saccharin over no saccharin. This preference was greater when either pellets or crumbles were offered than when meal was offered. In experiment II there was a significant ($P<.05$) linear increase in feed consumption (averaged over all forms of the ration) with increasing levels of saccharin.

The results of experiment III, which are shown in figure 4 support the previous experiments in that the pigs significantly ($P<.05$) preferred

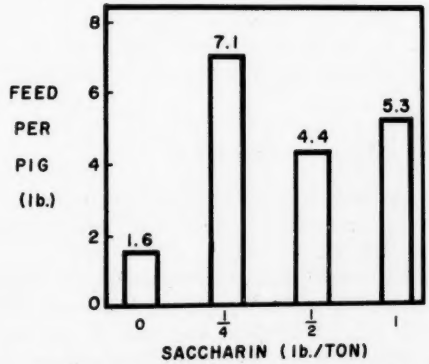


Figure 4. Experiment III. Effect of soluble saccharin on starter consumption by early weaned baby pigs.

saccharin in the ration. They consumed, on the average, 3.5 times as much of the saccharin rations as of the non-saccharin rations.

*Discussion*

These results are in harmony with the results of Lewis *et al.* (1955), Jensen *et al.* (1955) and Hanson *et al.* (1954) in so far as the baby pig's preference for some type of sweetness or sweetening agent is concerned.

In experiment II where five feeders containing the different levels of saccharin were placed in the same pen, no apparent consumption pattern was followed from week to week in the baby pig's preference for the different levels of saccharin. The variation between replications was also large. It seemed logical to conclude that when the baby pig was faced with a large number of choices, he was not able to discriminate between small differences in level of added saccharin. A more reliable test to determine if the pig could discriminate between two levels of saccharin should be obtained if the number of choices with which the pig was confronted was reduced.

In experiment III the relative consumption of each level of saccharin remained quite constant from week to week, whereas the relative consumption varied widely in experiments I and II where five choices were offered. Limiting the number of choices reduced the variability in feed preference.

One problem which may arise in palatability experiments is that certain individual animals may consistently prefer a feed different from the average of all animals. Hegsted *et al.* (1956) stated that this was true in work with cats. This finding, of course, poses some serious questions about palatability tests, since the results might be affected by choice of animals used. The answer to this problem would be the use of a large number of animals to minimize the effect of individuals which vary widely from the population.

## Summary

Three experiments involving 186 pigs were conducted to develop palatability testing techniques and to determine if the baby pig had a preference for a starter ration containing saccharin.

The pigs generally preferred a diet containing some level of saccharin compared to no saccharin and this preference was more pronounced when the feed was in the pellet or crumble form than in the meal form.

The best technique appeared to be one in which the baby pig has a minimum number of choices to make, and the rations have relatively wide differences.

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# GROWTH INHIBITORY EFFECT OF OAT HULLS IN RATIONS FOR GROWING-FINISHING SWINE

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VESTAL (1922), Bohstedt and Fargo (1933), Mitchell and Hamilton (1933), Mangold (1934), Crampton and Maynard (1938), Crampton and Bell (1946) and Forbes and Hamilton (1952) have reported trials which demonstrated the low nutritional value of oat hulls for swine. Crampton and Bell (1946) further suggested that fineness of grinding improved acceptability but not digestibility, although the hull might have a favorable physical or chemical effect on the utilization of the non-hull portion of the diet.

Jensen *et al.* (1959) showed that oats varied markedly in feeding value when replacing equal weights of corn in complete mixed rations for growing-finishing swine. Comparison of 24- and 32-lb. test-weight oats demonstrated the lower feeding value of the lighter oats. Replacing corn at various levels did not improve, and in most cases inhibited performance as measured by growth rate and feed conversion. The tests reported here were designed to ascertain whether the hull fraction was responsible for this growth depressing effect.

## Experimental

Four experiments each involving 18 pigs and one experiment involving 36 pigs were conducted. The first four experiments were of 28 days duration. Experiment 5 lasted 46 days. Crossbred pigs were used in all but experiment 5, which employed Durocs. All animals were fed twice daily in individual floor pens. Adequate shelter was provided and the animals had access to automatic waterers except when in the individual pens at feeding time. At each feeding the rations were moistened to encourage feed consumption.

Outcome groups were formed on the basis of ancestry, weight, condition and previous treatment. Pigs within outcome groups were randomly allotted among treatments. Gain and feed data were recorded weekly.

The ingredients used in the control diets are shown in table 1. All diets within an experiment were formulated to contain calculated equal protein levels. Total digestible nutrient (TDN) content of rations was calculated

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TABLE 1. COMPOSITION OF CONTROL DIETS

| Ingredient | Diet fed in experiment | | | |
|---|---|---|---|---|
| | 1 and 2 | 3 | 4 | 5 |
| | % | % | % | % |
| Ground yellow corn | ..... | 85.40 | 77.50 | 77.55 |
| Solvent soybean oil meal | ..... | 11.50 | 18.50 | 18.50 |
| Hulled oats | 96.80 | ..... | ..... | ..... |
| Dicalcium phosphate | 1.00 | 1.55 | 1.55 | 1.50 |
| Ground limestone | 1.00 | 0.75 | 0.75 | 0.75 |
| Trace-mineralized salt | 0.50 | 0.50 | 0.50 | 0.50 |
| Vitamin supplement [a] | 0.20 | 0.20 | 0.20 | 0.20 |
| Antibiotic-$B_{12}$ supplement [b] | 0.50 | .... | 1.00 | 1.00 |
| Antibiotic [c] | .... | 0.10 | .... | .... |

[a] Contained 2 gm. of riboflavin, 4 gm. of pantothenic acid, 9 gm. of nicotinic acid, 90 gm. of choline chloride, 10 gm. of irradiated yeast (9000 I.U. per gm.), and 7.5 gm. of vitamin A acetate (250,000 I. U. per gm.). In experiment 3, the vitamin supplement also contained 9 mcg. of vitamin-$B_{12}$ activity per pound.

[b] Contained 1.8 gm. chlortetracycline hydrochloride and 1.8 mg. of vitamin $B_{12}$ activity per pound.

[c] Contained 7.5 gm. of bacitracin and 2.5 gm. of procaine penicillin per pound.

using the digestibility figures of the feedstuffs for swine as summarized by Schneider (1947).

## Results

The results of experiments 1 and 2 are shown in table 2. Considerable variation in performance was encountered within treatments; however, in

TABLE 2. RESPONSE OF PIGS TO HULLED OATS DIET, TO ADDITIONS TO HULLED OATS DIET, AND TO CORN-SOYBEAN OIL MEAL DIET IN EXPERIMENTS 1 AND 2 [a]

| Diet | Additions to hulled oats diet | | | | | | |
|---|---|---|---|---|---|---|---|
| | Hulled oats diet | 15% Hulls | 30% [b] Hulls | 30% Hulls 14% Corn oil [c] | 10% Cellulose [d] | Corn—SBOM diet | |
| Av. daily gain, lb. | | | | | | | Av. |
| Exp. 1 | 1.21 | 0.89 | 0.88 | 1.24 | 1.26 | 1.34 | 1.14 |
| Exp. 2 | 1.33 | 1.19 | 0.77 | 1.18 | 1.06 | 1.60 | 1.19 |
| Av. | 1.27 | 1.04 | 0.82 | 1.21 | 1.16 | 1.47 | |
| Feed per lb. gain, lb. | | | | | | | |
| Exp. 1 | 3.40 | 4.48 | 4.18 | 3.18 | 3.18 | 3.21 | 3.60 |
| Exp. 2 | 3.33 | 3.65 | 3.80 | 2.84 | 3.56 | 2.51 | 3.28 |
| Av. | 3.36 | 4.06 | 3.99 | 3.01 | 3.37 | 2.86 | |
| Av. daily feed, lb. | | | | | | | |
| Exp. 1 | 4.11 | 3.99 | 3.68 | 3.94 | 4.01 | 4.30 | 4.00 |
| Exp. 2 | 4.43 | 4.34 | 2.93 | 3.35 | 3.77 | 4.02 | 3.81 |
| Av. | 4.27 | 4.16 | 3.30 | 3.64 | 3.89 | 4.16 | |

[a] Three individually fed pigs per treatment in each experiment. Average initial weights were approximately 107 and 109 lb., respectively.

[b] This quantity represents the hulls removed from the oats used in diet 1.

[c] Corn oil was added to provide ration TDN equivalent to hulled oats ration.

[d] Ten percent cellulose calculated to be approximately equivalent to 30% hulls in crude fiber value.

TABLE 3. ANALYSIS OF VARIANCE, EXPERIMENTS 1 AND 2

| Source | d.f. | Mean squares | | |
|---|---|---|---|---|
| | | Gains | Feed/lb. gain | Daily feed |
| Experiment (E) | 1 | 0.0220 | 0.9570* | 0.1431 |
| Treatment (T) | 5 | 0.2836** | 1.4680** | 0.9398* |
| E×T | 5 | 0.0628 | 0.2899 | 0.3105 |
| Outcome group | 4 | 0.1145* | 1.0062** | 0.4764 |
| Remainder | 20 | 0.0290 | 0.1580 | 0.2881 |

* $P<0.05$.
** $P<0.01$.

both experiments, adding oat hulls decreased rate of gain. The addition of 10% cellulose had no effect on gain in experiment 1 but decreased gain in experiment 2. Combining the data, the two experiments show reductions in daily gain of 18 and 35%, respectively, with the additions of 15 and 30% oat hulls. Adding 14% crude corn oil to the 30% oat hulls diet resulted in gains similar to those on the hulled oats diet. The corn-soybean oil meal diet produced the most rapid gains.

Adding oat hulls resulted in more feed required per pound of gain, while 10% cellulose did not affect average feed efficiency. The deleterious effect of 30% oat hulls was more than overcome by the addition of 14% crude corn oil. The most efficient gains, 2.86 lb. of feed per pound of gain, were realized on the corn-soybean oil meal ration. Feed consumed per day was depressed by addition of oat hulls and cellulose. Analysis of variance of the pooled data for experiments 1 and 2 are shown in table 3. Treatment significantly affected rate of gain ($P<0.01$), daily feed ($P<0.05$), and feed per pound of gain ($P<0.01$).

Experiment 3 was designed to study the effect of additions of oat hulls, cellulose and crude corn oil to the corn-soybean oil meal diet shown in table 1. Data in table 4 show the growth-inhibiting effect of oat hulls in the ration. Ten percent cellulose and 15% oat hulls reduced gains the same amount. The addition of crude corn oil to the 30% oat hulls ration

TABLE 4. RESPONSE OF PIGS TO ADDITIONS TO CORN-SOYBEAN OIL MEAL DIET IN EXPERIMENT 3 [a]

| Diet and additions | Corn—SBOM | 15% Hulls | 30% Hulls | 30% Hulls 14% Corn oil | 10% Cellulose | 10% Cellulose 8% Corn oil |
|---|---|---|---|---|---|---|
| Av. daily gain, lb.[b] | 1.52 | 1.32 | 0.97 | 1.22 | 1.32 | 1.56 |
| Feed/lb., gain, lb. | 3.01 | 3.42 | 4.15 | 3.15 | 3.38 | 2.78 |
| Feed/day, lb. | 4.56 | 4.53 | 4.04 | 3.84 | 4.47 | 4.33 |

[a] Average initial weight was approximately 97 lb.
[b] Each figure represents performance of six individually fed pigs.

TABLE 5. ANALYSIS OF VARIANCE, EXPERIMENT 3

| Source | d.f. | Mean squares | | |
|---|---|---|---|---|
| | | Gains | Feed/lb. gain | Daily feed |
| Treatment (T) | 5 | 0.2706*** | 1.3280*** | 0.5187** |
| Outcome group (O) | 5 | 0.0266 | 0.1494* | 0.7309*** |
| T×O | 25 | 0.0146 | 0.0497 | 0.1113 |

* $P<0.05$.
** $P<0.01$.
*** $P<0.001$.

did not completely overcome the growth inhibition, but feed per day was only 3.84 lb. as compared to 4.56 lb. on the control diet. Crude corn oil, 8%, prevented growth inhibition by 10% cellulose. Most efficient gains among the treatments were obtained on the 10% cellulose plus 8% crude corn oil diet. Analysis of variance (table 5) shows that ration treatment significantly affected average daily gains and feed per pound of gain ($P<0.001$) and daily feed ($P<0.01$).

TABLE 6. RESPONSE OF PIGS TO ADDITIONS TO CORN-SOYBEAN OIL MEAL DIET IN EXPERIMENT 4 [a]

| Diet and additions | Corn—SBOM | 7% Hulls | 7% Hulls 3% Corn oil | 7% Hulls 0.1% Bovirum [b] | 2.5% Cellulose | 2.5% Cellulose 0.1% Bovirum [b] |
|---|---|---|---|---|---|---|
| Av. daily gain, lb. | 1.39 | 1.13 | 1.40 | 1.11 | 1.18 | 1.17 |
| Feed/lb. gain, lb. | 2.48 | 2.72 | 2.23 | 2.56 | 2.52 | 2.25 |
| Feed/day, lb. | 3.45 | 3.07 | 3.12 | 2.84 | 2.97 | 2.63 |

[a] Three individually fed pigs per treatment. Average initial weight approximately 49 lb.
[b] A dried product of natural and cultured rumen bacteria.

Experiment 4 was designed to study the response of 50 lb. pigs to oat hull additions. Further, it was desired to evaluate a dried product of natural and cultured rumen bacteria (Bovirum) for enzymatic activity in the pig. The results are shown in table 6. Seven percent oat hulls, calculated equivalent to that in a ration containing 20% whole oats, markedly reduced growth rate and this deleterious effect was overcome by 3% corn

TABLE 7. ANALYSIS OF VARIANCE, EXPERIMENT 4

| Source | d.f. | Mean squares | | |
|---|---|---|---|---|
| | | Gains | Feed/lb. gain | Daily feed |
| Treatment (T) | 5 | 0.0519 | 0.1095 | 0.2145 |
| Outcome group (O) | 2 | 0.0162 | 0.1766 | 0.0435 |
| T×O | 10 | 0.0354 | 0.2292 | 0.5376 |

TABLE 8. RESPONSE OF PIGS TO ADDITIONS TO CORN-SOYBEAN OIL MEAL DIET AND TO RATE OF FEEDING IN EXPERIMENT 5 [a]

| Additions and rate of feeding [b] | Corn—SBOM (X) | 13% Hulls (X) | 13% Hulls (1.103X) [c] | 13% Hulls 5% Corn oil (X) | 13% Hulls 0.1% Bovirum (X) | 13% Hulls (Self-fed) |
|---|---|---|---|---|---|---|
| Av. daily gain, lb. | 1.02 | 0.93 | 1.01 | 1.06 | 0.96 | 1.28 |
| Feed/lb. gain, lb. | 2.81 | 3.07 | 3.10 | 2.69 | 2.99 | 2.88 |
| Feed/day, lb. | 2.85 | 2.85 | 3.13 | 2.85 | 2.85 | 3.68 |
| TDN/lb. gain, lb. | 2.15 | 2.13 | 2.17 | 2.06 | 2.07 | 2.00 |
| TDN/day, lb. | 2.18 | 1.98 | 2.17 | 2.18 | 1.98 | 2.55 |

[a] Three individually fed pigs per treatment. Average initial weight approximately 50 lb.
[b] Initial daily X level of feeding was 2 lb. per pig. This value was increased weekly as determined by the daily consumption of the least acceptable ration.
[c] 1.103X level of feeding provided calculated TDN intake equal to X level of the Corn—SBOM diet.

oil. A level of 2.5% cellulose had a growth depressing effect similar to that of 7% oat hulls. The addition of 0.1% Bovirum did not improve growth rate on the high-fiber rations. Feed sorting and wastage by the pigs contributed to the wide variation in feed data. Analysis of variance (table 7) shows no statistically significant difference.

Experiment 5 compared equal feed, equal TDN, and self-determined intake to get more precise gain and feed efficiency data. The results are in table 8. Thirteen percent hulls decreased growth rate and increased feed per pound of gain. Five percent corn oil or increased daily feed (1.103X)[2] produced gains equal to the control ration. The self-fed pigs produced the most rapid gains. Bovirum had no statistically significant effect on performance. When the daily TDN intakes were identical, rates of gain and TDN per pound of gain were similar for the different rations. Table 9 shows that treatment significantly affected gains, daily feed and daily TDN ($P<0.01$). Differences in TDN per pound of gain were not statistically significant.

TABLE 9. ANALYSIS OF VARIANCE, EXPERIMENT 5

| Source | d.f. | Mean squares: Gains | Feed/lb. gain | Daily feed | TDN/lb. gain | TDN/day |
|---|---|---|---|---|---|---|
| Treatment (T) | 5 | 0.0453** | 0.0823 | 0.3346** | 0.0126 | 0.1300** |
| Outcome group (O) | 2 | 0.0308* | 0.2538 | 0.0322 | 0.0333 | 0.0155 |
| T×O | 10 | 0.0047 | 0.0664 | 0.0322 | 0.0581 | 0.0155 |

* P=0.05.
** P=0.01.

[2] This quantity of the 13%-oat-hulls-ration provided calculated TDN equal to an X level of the corn-SBOM ration.

*Discussion*

The levels of oat hulls fed in these trials were comparable to those in the oats rations evaluated by Jensen *et al.* (1959). The present report confirms the opinion that the growth reduction caused by oats in rations of growing-finishing swine was the result of lowered TDN value and feed intake.

Adding hulls to hulled oat rations decreased growth rate and feed efficiency. Addition of corn oil to equate the rations for TDN resulted in gains comparable to those on the control diet.

Including oat hulls in corn-soybean oil meal diets depressed pig performance. Calculated TDN values were reduced when hulls were added, and the pig did not consume a greater quantity of diet to make up for the reduced TDN value, contrary to the suggestion of Axelsson and Eriksson (1953). Instead, acceptability of the ration was adversely affected as indicated by lowered total feed intake. Correction of calculated TDN deficiency by additions of corn oil counteracted the depression in feed efficiency and prevented the growth reduction when feed consumption was comparable to the control rations. With controlled feed intake, corn oil additions prevented growth depression and resulted in improved feed efficiency. These results are similar to those reported by Hanson *et al.* (1956) who concluded that the growth-inhibiting effect of dehydrated alfalfa meal was due largely to the lowered total digestible nutrient content of the diet and to a lowered feed intake by the pig.

The addition of a dried product of natural and cultured rumen bacteria (Bovirum) did not apparently affect utilization of oat hulls. When rations were fed *ad libitum* feed consumption was reduced when Bovirum was added at a level of 0.1%. However, bacterial fermentation may play a role in the digestion of such fibrous materials, as indicated by Forbes and Hamilton (1952) who demonstrated a significant decrease in digestion coefficients of the crude fiber and cellulose of alfalfa meal when a bacteriostatic agent was included in the ration.

## Summary

The growth-inhibiting effect of oat hulls in rations for growing-finishing swine was studied in five experiments involving 108 individually-fed pigs. Adding hulls at levels of 15 and 30% to hulled-oat rations or to corn-soybean oil meal rations significantly reduced growth rate and feed efficiency of 100-lb. pigs. With 50-lb. pigs, 7 and 13% hulls markedly depressed performance.

Adding 0.1% of a dried rumen product to rations containing hulls had no apparent beneficial effect.

When crude corn oil was added to provide calculated TDN equal to the control rations, the growth-inhibiting effect of the hulls was largely overcome. Controlling the daily TDN intake of 50-lb. pigs resulted in

similar gains and feed efficiencies when rations of different hull percentages were fed.

The results suggest that the growth-inhibiting effect of oat hulls is mediated through the dilution of TDN value of the ration and lowered feed intake.

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# EFFECT OF CONSTANT ENVIRONMENTAL TEMERATURES, 50° AND 80° F., ON APPEARANCE OF PUBERTY IN BEEF CALVES [1]

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BIRTH in many species occurs at a season of favorable temperature and abundant food supply; mating is stimulated by an event, usually climatic, that precedes this season by the length of the gestation period. In many of the more specialized animals that have a breeding season, sex activity is related to change in the exposure to light and dark (Rowan, 1925; Bissonnette and Bailey, 1936).

In animals that do not have a breeding season, i.e., those animals that have estrous cycles at regular intervals throughout the year (usually animals evolved under fairly uniform climatic conditions or domestic animals protected from climatic and nutritional extremes) there are nonethe-less seasonal differences in the incidence of birth (Edwards, 1938; Erb and Waldo, 1952). These are partly economic seasons in domestic animals; they are partly seasonal variations in fertility of both males and females due to the effect of altered nutrition, temperature extremes, and light on pituitary and gonadal activity (Mercier and Salisbury, 1947; Asdell, 1953; Dutt *et al.*, 1956).

The following experiment was conducted to determine the effects of prolonged exposure to a thermally stressful temperature (80° F.) on the ovarian activity of beef calves.

## Experimental Procedure

Santa Gertrudis, Brahman, and Shorthorn heifer calves (three of each) were raised from about one month of age at a constant environmental temperature of 50° F.; a similar group was raised at 80° F. A control group of calves (three to six heifers of each breed) was kept under the usual Missouri housing conditions with daily exposure to Missouri weather. Details of the Climatic Laboratory, the calves, and the feeding and management practices have been published (Ragsdale *et al.*, 1957).

The ovaries and internal genitalia of the calves were examined by rectal palpation on alternate days. The recording, processing, and interpretation of the data are discussed in detail elsewhere (Dale *et al.*, 1959). Time of puberty was estimated by the size and persistence of structures, either follicles or corpora lutea, on the surface of the ovary.

[1] Supported in part by the U. S. Atomic Energy Commission.
[2] Departments of Veterinary Physiology and Dairy Husbandry. Acknowledgement is made of the technical assistance of G. T. Barrows, C. W. Grosse, J. P. McGinnis, and P. L. Nicoletti.
[3] Contribution from the Missouri Agricultural Experiment Station, Journal Series Number 1918. Approved by the Director.

## Results and Discussion

Prior to puberty the ovary presented either a smooth surface or the granular feeling of numerous underdeveloped or atretic follicles; after puberty there were usually one or more structures on the surface of the

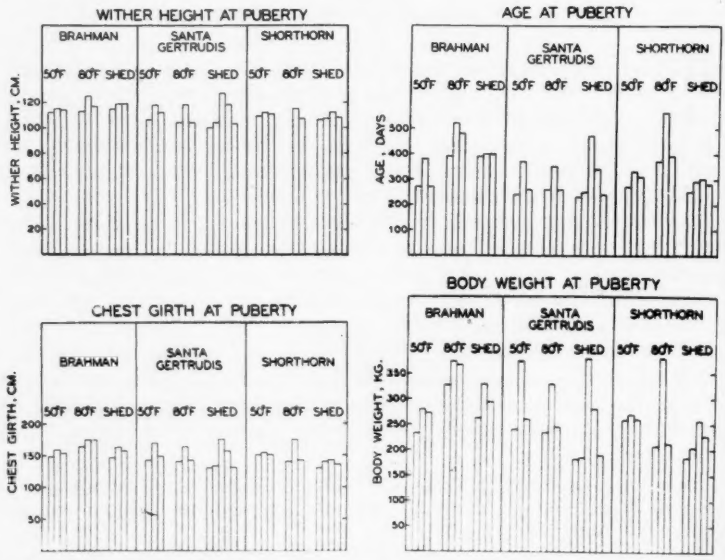


**Figure 1. Individual measurements at the time of puberty in Brahman, Santa Gertrudis, and Shorthorn calves raised at 50° and 80° F. and under the usual Missouri open shed housing conditions.**

ovary which were large and persistent enough to indicate a mature follicle or corpus luteum.

The exceptions to this were one 50° Braham and all but one of the open shed Brahmans where after one or two ovarian cycles (i.e. ovulation and the formation of a corpus luteum) in the fall, September and October, the ovaries again presented a surface without structures large enough to be functional. This period of ovarian activity, although followed by anestrus, was regarded as the time of puberty in these calves.

As shown in figure 1, age and body weight were more variable at the time of puberty than were wither height and chest girth. This is in part because in growing to puberty there is smaller percentage change in wither height and chest girth than in age and body weight. None-the-less, the calves at puberty were close to the same stature, despite the fact that they reached this stature at quite different ages and with considerable variation in the amount of soft tissue. This leads to the conclusion that

in so far as environmental temperature affects growth rate, it affects the age at which puberty appears.

Calves grow at different rates and ultimately reach different sizes. An informative relationship is shown in table 1 where the mean value at puberty is expressed as a percent of the predicted mature value (Ragsdale *et al.*, 1957). Disregarding for a moment the open shed calves of all breeds, it is apparent that in terms of percent of predicted mature value, puberty was delayed in the 80° F. Brahman calves, a breed where growth was more rapid at 80° than at 50° F. In the Shorthorns the effect was similar but

TABLE 1. MEAN VALUES AT THE TIME OF PUBERTY OF BRAHMAN, SANTA GERTRUDIS, AND SHORTHORN HEIFER CALVES RAISED AT CONSTANT ENVIRONMENTAL TEMPERATURES OF 50° AND 80° F. AND UNDER THE USUAL MISSOURI OPEN SHED HOUSING CONDITIONS [a]

| | Brahman | | | Santa Gertrudis | | | Shorthorn | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | 50° | 80° | Open | 50° | 80° | Open | 50° | 80° | Open |
| No. Animals | 3 | 3 | 3 | 3 | 3 | 5 | 3 | 3 | 4 |
| Age, days | 307 | 463 | 397 | 290 | 290 | 306 | 303 | 440 | 280 |
| | (12) | (19) | (17) | (13) | (11) | (12) | (11) | (14) | (9) |
| Body weight, kg. | 261 | 357 | 296 | 295 | 269 | 243 | 263 | 267 | 219 |
| | (44) | (60) | (50) | (43) | (39) | (36) | (39) | (45) | (32) |
| Wither height, cm. | 114 | 118 | 118 | 112 | 109 | 110 | 111 | 111 | 108 |
| | (83) | (95) | (86) | (82) | (80) | (77) | (80) | (81) | (75) |
| Chest girth, cm. | 154 | 171 | 156 | 153 | 148 | 145 | 152 | 152 | 137 |
| | (74) | (84) | (77) | (71) | (69) | (66) | (69) | (75) | (63) |

[a] The number in parenthesis expresses the mean value at puberty as percent of the predicted mature value. Predicted mature values can be found in Mo. Agr. Exp. Stat. Res. Bul. 642.

not as pronounced. The Shorthorn data are distorted by one calf at 80° F.; this calf was about 100 lb. heavier than the other 80° Shorthorns at similar age, yet she did not reach puberty until 560 days of age compared to 370 and 380 days of age for the other 80° Shorthorn calves. In both cases, i.e., 80° Brahmans and the one 80° Shorthorn, where heat tolerance was indicated by a rapid growth rate, puberty was delayed when these calves are compared to calves of the same breed at 50° or to the two heat intolerant Shorthorns at 80° F. In this instance there would appear to be a more direct relationship between environmental temperature and hypophyseal-gonadal activity.

The open shed Brahmans appeared to have a breeding season in September and October. Here puberty presumably represented an interaction between body size and environment (Asdell, 1946); however, the one calf which did not mature sexually was one of the larger calves of this group.

The Shorthorns reached puberty at an earlier age and smaller size in the open shed than at either 50° or 80° F.; this is apparent in both absolute values and as percent of the predicted mature value (table 1). Time of puberty in the Santa Gertrudis calves did not seem to be much affected by climatic conditions.

## Summary

Brahman, Santa Gertrudis, and Shorthorn heifer calves were raised from one month of age at constant environmental temperatures of 50° and 80° F., relative humidity of 50–70%, with equal periods of light and dark (experimental calves); controls were kept in an open shed exposed to Missouri weather.

One outdoor Brahman did not mature; the remaining outdoor Brahmans and one 50° Brahman were apparently seasonally monestrous. All other calves were polyestrous.

Brahmans at 80° reached puberty at a mean age of 463 days (19% of predicted age at mature weight); mean ages of all other experimental groups were between 290 and 440 days (11 to 14% of predicted age at mature weight). At puberty 80° Brahmans had achieved a mean of 60% of predicted mature weight (compared to means of 39 to 45% for all other experimental groups), a mean of 95% of predicted mature wither height (compared to means of 80 to 83% for all other experimental groups), and a mean of 84% of predicted mature chest girth (compared to means of 69 to 75% for all other experimental groups).

One Shorthorn at 80° F. was similar to the 80° F. Brahmans in that superior heat tolerance, as indicated by rate of growth, was accompanied by delayed puberty.


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# EFFECTS OF MODIFIED SUMMER ENVIRONMENT ON SWINE PERFORMANCE [1]

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IT is common knowledge that swine do not perform well in hot summer weather. Their performance has been studied in the California Psychrometric Chamber (Heitman, Kelly and Hughes, 1949) under controlled conditions, and it has been reported that daily weight gain may be reduced when constant ambient temperatures reach 75° to 80° F. (Heitman and Hughes, 1949; Heitman, Kelly and Bond, 1958).

One of the cooling devices for swine, best known to growers, is the wallow, which makes use of the natural instinct of swine to cool themselves. Rapid cooling effected by evaporation of water from a pig's surface has been reported (Heitman and Hughes, 1949). An increase in daily gain of 0.4 lb. due to the use of a summer wallow has been reported by Bray and Singletary (1948). Sprays have been compared with and found as effective as wallows (Andrews *et al.*, 1956, 1957).

There is otherwise a general lack of information on field modification of summer environment for swine. In the Psychrometric Chamber it has been consistently possible under optimum conditions to obtain gains of 2 lb. or more per day (Heitman *et al.*, 1958). However, pigs from the same herd fed similar rations failed to reach this rate under naturally varying conditions (Heitman and Clegg, 1957). Such difference in daily gain is a measure of what can be done in the future with proper management and housing, and invites research in this important field.

## Experimental

The experimental animals were housed in outdoor concrete pens 24′ x 48′, except lot 6 which was housed in a 10′ x 24′ concrete-floored pen in the farrowing barn. Each outdoor pen contained an 8′ x 12′ three-sided house (corrugated metal roof, plank floor approximately 4″ above concrete pen). The three-sided houses were oriented so that the open side faced north. Each outside pen (except lot 5) also had an 8′ x 12′ fabric shade [5]

[1] This study was conducted as part of a cooperative project between the Agricultural Research Service, U. S. Department of Agriculture, and the Departments of Animal Husbandry and Agricultural Engineering, University of California, Davis.

[2] Department of Animal Husbandry.

[3] A.E.R.D. Agricultural Research Service, U. S. Department of Agriculture stationed at Davis.

[4] Department of Agricultural Engineering.

[5] The neoprene shades were used to enable the air stream of the fan in lot 4 to be directed under shade. Similar shades were therefore used in other outside lots.

(neoprene, aluminized upper surface, 6′ high) suspended between the house and east pen fence. The fences were constructed of spaced 1″ x 6″ lumber and provided some shade when the sun was low. All pens contained an automatic watering device and self feeder.

The treatments were as follows:

Lot 1—Control.

Lot 2—Wallow [6]—a 5′ x 10′ portable steel wallow was placed in the open pen area in the sun.

Lot 3—Shaded wallow—same type wallow as lot 2, but with a neoprene shade over it. This neoprene shade was in addition to the 8′ x 12′ one.

Lot 4—Fanned wallow—same type wallow as in lots 2 and 3. A 36″ fan was mounted on the south fence (facing north with the prevailing breeze) to increase air flow under the 8′ x 12′ neoprene shade. The fan was on a time switch to operate from 10 a.m. to 6 p.m. daily.

Lot 5—Air-conditioned house—a 6′ x 10′ x 4′ insulated house with two one-ton (nominal capacity) air-conditioning units was placed in the open pen area. The cooled and slightly dehumidified air entered the rear of the house and was discharged through the open front door (no recirculation). One unit was controlled by thermostat to operate above 70° F.; the other, above 75° F.[7]

Lot 6—Indoors—pigs were housed in 10′ x 24′ pen in northwest corner of large farrowing barn.

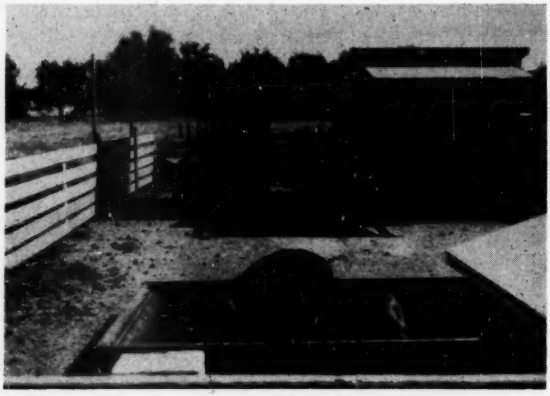

**Figure 1. Pen layout as illustrated by picture of lot 4. This view shows the neoprene shade, fan, three-sided house, wallow, and self feeder (extreme right foreground).**

[6] Two commercial steel wallows were generously donated by the Leland Machine Shop, Leland, Illinois, for this study.

[7] After July 10 the units were connected through a time clock to eliminate night time recycling. The clock allowed thermostatic operation from 8 a.m. to 10 p.m.

The experiment was started July 3, 1958, with pigs averaging 82.3 lb. It ran for 70 days, ending September 11, except that lot 6 was discontinued August 28 after 56 days. There were 9 pigs in each of lots 1 to 5 and 5 pigs in lot 6 at the start of the experiment. One pig in each of lots 3 and 5 had to be removed owing to conditions not related to the experiment. Pigs were purebred Duroc barrows and gilts, each sex being assigned at random to lot and treatment. The composition of the rations [8] in percent was as follows: (1) from start to 135 lb.; ground barley, 80; dehydrated alfalfa meal, 5; soybean meal, 3.5; cottonseed meal, 3.5; meat and bone scraps (50% protein), 7.5; NaCl, 0.5; (2) from 135 lb. to conclusion; ground barley, 86; dehydrated alfalfa meal, 5; soybean meal, 1; cottonseed meal, 1; meat and bone scraps (50% protein), 6; oystershell flour, 0.5; NaCl, 0.5.

## Results and Discussion

The environment is briefly described in table 1. Even though the average mean temperature was only 75° F., the maximum temperature was over 100° F. for 17 days; 95° F., 42 days; 90° F., 54 days; and 85° F., 64 days. Air conditioning lowered the average mean temperature in the air-conditioned house during the test period 3.5° F. as compared to the air temperature outside but it lowered the average maximum temperature 13.5° F. Air

TABLE 1. SUMMARY OF EXPERIMENTAL ENVIRONMENT [a]

| Lot | Average air temperature, ° F. | | | Average air relative humidities, % | | |
|---|---|---|---|---|---|---|
| | Maximum | Mean [b] | Minimum | Maximum | Mean [b] | Minimum |
| Outside (lots 1 to 4) | 94.4 | 75.0 | 58.5 | 90.9 | 54.8 | 26.3 |
| Air-conditioned house (lot 5) | 80.9 | 71.5 | 58.5 | .... | .... | .... |
| Indoor (lot 6) | 94.6 | 77.6 | 64.4 | 70.8 | 52.8 | 32.4 |
| | | | | Air velocity, mph [c] | | |
| Control (lot 1) | | | | 2.4 | | |
| Fanned wallow (lot 4) [d] | | | | 8.5 | | |
| Indoors (lot 6) | | | | negligible | | |
| | | | | Temperature of wallow water, ° F. [e] | | |
| Wallow (lot 2) | | | | 100.5 | | |
| Shaded wallow (lot 3) | | | | 89.0 | | |
| Fanned wallow (lot 4) | | | | 96.3 | | |
| Air temperature [f] | | | | 91.8 | | |

[a] Temperature and relative humidity recorded continuously.
[b] Average of readings from recording hygrothermograph taken at 2-hr. intervals.
[c] Average of 21 random measurements made in the late mornings or early afternoons.
[d] Measured under 8' x 12' neoprene shade in air stream from fan.
[e] Average of weekly checks.
[f] At time of wallow temperature checks.

[8] Plus 0.45 lb. zinc sulphate per ton ration.

conditioning was more effective than these values indicate because the system was inoperative during parts of 10 days during the test. Also, on 26 days the maximum temperature in the air-conditioned hog house occurred after 10 p.m. when the time clock had turned off the units and most of the pigs were out of the house. During the time the units were running, the average temperature in the air-conditioned house was 70.1° F. The mean indoor temperature (lot 6) was actually higher than outside (due to a higher average minimum temperature), and the diurnal environmental variation was less. The fan increased air velocity about 6 mph over the prevailing breeze in the outside pens, whereas there was negligible air movement in the indoor pen. The shade over the wallow apparently

TABLE 2. RESPONSE OF PIGS TO MODIFIED SUMMER CONDITIONS (70 DAYS)

| Lot number | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Treatment | Control | Wallow | Shaded wallow | Fanned wallow | Air-conditioned house | Indoors |
| No. of pigs | 9 | 9 | 8 | 9 | 8 | 5 |
| Av. initial wt., lb. | 82.9 | 87.3 | 80.8 | 79.6 | 80.8 | 81.6 |
| Av. total gain, lb. | 91.1[a] | 103.8 | 105.5 | 100.2 | 102.2 | 80.8[b] |
| Av. daily gain, lb./pig | 1.30 | 1.48 | 1.51 | 1.43 | 1.46 | 1.44 |
| Av. daily feed, lb./pig | 5.40 | 5.62 | 6.10 | 5.77 | 4.97 | 5.74 |
| Feed per lb. gain, lb. | 4.15 | 3.80 | 4.02 | 4.03 | 3.40 | 4.00 |

[a] Analysis of variance showed mean square for total gain for lots 1 to 5 statistically significant at the 5% level. Total gain for lot 1 significantly lower than those of lots 2, 3, 4 and 5 by the Kramer (1956) modification of the Duncan (1955) multiple range test at the 5% level. Total gain for lot 1 significantly lower than those of lots 2 and 3 at the 1% level by the same test.

[b] This group discontinued after 56 days. Total gains for 56 days in lots 1 through 6 were 70.7, 80.9, 79.5, 82.7, 83.2 and 80.8, respectively. Analysis of variance showed mean squares for total gains at 56 days for lots 1 to 6 to be statistically significant at the 5% level. Kramer (1956) modification of the Duncan (1955) multiple range test indicates that lot 1 gain differs from those of all other lots at 5% level and from those of lots 4 and 5 at the 1% level.

lowered the wallow water temperature. The wallow water in the fanned wallow pen also was lower in temperature due, possibly, to increased evaporation from the wallow as well as its color, reddish aluminum, as compared to black for the wallow in lot 2.

The effects of these different modified environments on animal behavior are being prepared for publication. The results as regards hog performance are summarized in table 2. All of the treatments were effective in that the pigs in these lots gained weight significantly faster than the controls during the course of the experiment. There were no significant differences among treatments, however. Feed consumption and utilization data cannot be subjected to statistical analysis as the animals were group fed, but all treatments appeared to cause an increase in feed consumption, except the air-conditioned house. It apparently required less feed to produce a pound of gain in all lots as compared to the controls.

Respiratory rates were observed among the various lots during the heat of the day when the air temperature varied from 90–97° F. The control pigs were breathing at a rate of 130–170 per minute while either in the house or under the fabric shade. The respiratory rate of all the wallow groups was about 45–75 per minute while under the 8′ x 12′ fabric shade. Pigs in the water in the shaded wallow breathed 25–45 times per minute while the rate for pigs in the water of wallows in the sun was 60–80 per minute. In the air-conditioned house and in the indoor pen the respiratory rate was approximately 60–90 per minute.

The amounts of water required to keep a depth of 4 inches in the steel wallows, as well as to drain them when cleaning, were 1120, 1120 and 1230 gal. respectively, in lots 2, 3 and 4 for the duration of the 70-day experiment. A continuous record of the operation of the air-conditioning units was maintained. During the experiment the 70° unit ran an average of 11.5 hours per day and the 75° unit 4.4 hours. The average daily kilowatt-hour consumption was calculated to be 16.1 and 6.2, respectively.

The results indicate that an ordinary wallow in the sun is as effective as any of the other treatments in increasing the rate of gain under the conditions of this experiment. The shaded wallow was no more effective, though there was some reduction of respiratory rate in this group during the heat of the day. The results with the fanned wallow group were disappointing in view of the results of increasing air movement over pigs with damp skins reported by Heitman and Hughes (1949). The air-conditioned house also failed to show any advantage over the wallow, though there was some indication that feed utilization in this group was greatest. The value of raising hogs in confinement indoors is shown by the results of lot 6. Whether this was due to the slightly smaller cyclical environmental change, a difference in radiant heat load, the reduced rate of air motion, or some other factor or combination of factors is not known.

## Summary

Results are reported of an experiment involving 48 growing-finishing pigs in confinement under California summer conditions with an average diurnal temperature range of 58.5 to 94.4° F. and an average mean temperature of 75.0° F. The following treatments were compared to a control lot: wallow in the sun, wallow in the shade, wallow combined with increased air motion, access to a small air-conditioned house, and confinement to a pen inside a large hog barn.

Over the 70-day experimental period all treated groups gained weight more rapidly (1.43 to 1.51 lb. per day) than the controls (1.30 lb. per day), but there were no significant differences between treatments. Food utilization appeared lowest in the control group and greatest in the group with access to the air-conditioned house.

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# EFFECT OF METHOD AND LEVEL OF IRON ADMINISTRATION ON GROWTH, HEMOGLOBIN AND HEMATOCRIT OF SUCKLING PIGS

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SEVERAL reports have established the effectiveness of iron-dextran given intramuscularly in treating and preventing anemia in baby pigs (Barber *et al.*, 1955; Brownlie, 1955; McDonald *et al.*, 1955; Rydberg *et al.*, 1959; Ullrey *et al.*, 1959). Two ml. (100 mg. of iron) were given at a few days of age in a single injection in most of these studies. Recent reports (Meade *et al.*, 1958; Conrad *et al.*, 1958) have indicated that a larger dose of iron may be more effective in promoting hemoglobin formation and growth under some conditions.

It was desired to compare injectable iron given at two dosage levels with oral iron as a means of preventing anemia in suckling pigs raised on concrete. It was also desired to observe the effects of extremely high doses of injected iron, since Behrens (1957) has reported iron toxicity of an injectable iron compound.

## Experimental Procedure

The pigs used were farrowed during 1958 and 1959, in a central hog house with a concrete floor. Sows were kept in a farrowing crate for the first two weeks of lactation and were then moved with their pigs to individual concrete pens each equipped with an outside concrete runway. Pigs had access to sow feed and to creep feed from approximately 3 weeks of age until they were weaned when 5–6 weeks old. Oat straw was used for bedding.

In trials 1 and 2 blood was taken from the anterior vena cava of each pig approximately 24 days of age for hemoglobin and hematocrit determination. In trial 3 blood was taken weekly for 5 weeks. Hemoglobin was determined by the method of Sanford and Sheard (1929) and hematocrit by the method of Wintrobe (1947). Body weights were recorded whenever blood samples were obtained. Pigs that lived less than three days were not included in the data. Statistical analyses were applied to the data using the methods of Snedecor (1956).

*Trial 1.* A total of 171 Berkshire, Chester White and Yorkshire pigs from 22 litters were used. Treatments were, treatment 1 (T1), saturated ferrous sulfate solution sprayed daily on udder of sow; (T2) intramuscular injection of 2 ml. (100 mg. iron) iron-dextran complex [1] into the ham at

[1] Iron-dextran (Armidexan) furnished by Dr. M. E. Davenport, Armour Laboratories, Chicago, Ill.

3–4 days of age; (T3) intramuscular injection of 2 ml. of the same iron-dextran complex at 3–4 days of age followed by a second 2-ml. injection at 10 days for a total of 200 mg. iron.

Approximately every third litter was assigned to the spraying treatment. Other litters were randomly divided so that one half of the pigs in each litter received one injection and the other half received two injections.

*Trial 2.* Eighty Chester White and Yorkshire pigs from seven litters were used. Treatments were, treatment 1 (T1), oral tablet given at 3 and at 10 days of age, each tablet supplying 292 mg. ferrous iron, 21.6 mg. copper sulfate and 2.85 mg. cobalt sulfate so that a total of 584 mg. of iron was supplied by the two tables; (T2), one intramuscular injection of 2 ml. of iron-dextran at 3 days of age as in trial 1 (100 mg. iron); (T3), two intramuscular injections of 2 ml. each at 3 and at 10 days of age as in trial 1 (200 mg. iron).

*Trial 3.* Seventeen Yorkshire pigs from two litters, 3 and 7 days old, were allotted on the basis of hemoglobin to four levels of intramuscular iron-dextran. These were, treatment 1 (T1), 2 ml. (100 mg. iron); (T2), 4 ml. (200 mg. iron); (T3), 8 ml. (400 mg. iron); and (T4), 10 ml. initially and 10 ml. one week later (total of 1,000 mg. iron). Blood samples were taken weekly for 5 weeks for hemoglobin determination. Body weight of each pig was recorded twice weekly.

## Results and Discussion

The results of trial 1 are summarized in table 1. Covariance analysis was used to adjust for differences in initial (birth) weight. Significant differences were obtained among treatments in hematocrit ($P<0.05$) and in hemoglobin ($P<0.01$). Differences in weight gain were not significant even though the average 24-day weight of pigs given a single iron injection (T2) was 1.0 lb. less than that of pigs receiving two injections (T3) and 1.3 lb. less than those receiving iron orally (T1). No significant sex differences were obtained in any of the criteria measured. The results indicate that a level of 100 mg. of iron was not sufficient to promote maximum hemoglobin synthesis, although all treatments were effective in preventing extremely low levels of hemoglobin.

The results of trial 2 are summarized in table 2. Covariance analysis to adjust for differences in initial weight revealed highly significant differences among treatments ($P<0.01$) in hemoglobin and in hematocrit. Again, no statistically significant differences occurred in growth rate among treatments. There were no sex differences in any of the criteria measured. Results from three untreated pigs are included in table 2 for comparison. These pigs became anemic (table 2) and showed scouring during the third week. The orally supplemented pigs had low hemoglobin and also showed mild scouring. This agrees with the concept of lowered resistance to disease in anemic pigs as demonstrated by Sheffy (1958). That oral administra-

TABLE 1. INJECTED IRON VERSUS SPRAYING THE SOW'S UDDER WITH IRON

| Item | Daily spraying[a] | | | One injection[b] | | | Two injections[c] | | | Standard deviation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Males | Females | Combined | Males | Females | Combined | Males | Females | Combined | |
| No. of pigs | 32 | 24 | 56 | 31 | 26 | 57 | 30 | 28 | 58 | .... |
| Av. birth weight, lb. | 2.7 | 2.7 | 2.7 | 2.5 | 2.6 | 2.6 | 2.7 | 2.6 | 2.7 | .... |
| Av. bleeding weight, lb. | 12.4 | 12.4 | 12.4 | 11.7 | 10.4 | 11.1 | 12.6 | 11.6 | 12.1 | .... |
| Total gain, lb. | 9.7 | 9.8 | 9.7 | 9.2 | 7.8 | 8.5 | 9.9 | 9.0 | 9.5 | 2.42 |
| Av. hemoglobin, gm./100 ml.** | 9.55 | 9.96 | 9.73 | 9.33 | 8.99 | 9.12 | 9.66 | 9.99 | 9.82 | 1.29 |
| Av. hematocrit* | 31.1 | 33.8 | 32.3 | 29.9 | 28.8 | 29.4 | 31.0 | 32.3 | 31.6 | 5.23 |

* Significant difference among treatments ($P<0.05$).
** Highly significant difference among treatments ($P<0.01$).
[a] Sow's udder sprayed daily with saturated ferrous sulfate solution.
[b] Intramuscular injection of 2 ml. iron-dextran to supply 100 mg. iron at 3–4 days of age.
[c] Intramuscular injection of 2 ml. iron-dextran at 3 days and 10 days to supply a total of 200 mg. iron.

TABLE 2. INJECTED IRON VERSUS ORAL IRON TABLETS

| Item | Untreated | Oral tablets[a] | | | One injection[b] | | | Two injections[c] | | | Standard deviation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Males | Females | Combined | Males | Females | Combined | Males | Females | Combined | |
| No. of pigs | 3 | 11 | 18 | 29 | 9 | 11 | 20 | 11 | 17 | 28 | .... |
| Av. birth wt., lb. | 2.4 | 2.7 | 2.6 | 2.6 | 2.7 | 2.8 | 2.8 | 2.7 | 2.7 | 2.7 | .... |
| Av. bleeding wt., lb. | 10.0 | 12.3 | 10.8 | 11.4 | 12.3 | 11.3 | 11.7 | 11.8 | 11.9 | 11.8 | .... |
| Total gain, lb. | 7.6 | 9.6 | 8.2 | 8.7 | 9.6 | 8.4 | 9.0 | 9.1 | 9.3 | 9.2 | 1.84 |
| Av. hemoglobin, gm./100 ml.** | 6.17 | 8.61 | 7.63 | 8.00 | 9.28 | 9.85 | 9.59 | 11.21 | 11.30 | 11.26 | 1.32 |
| Av. hematocrit** | 13.3 | 24.6 | 22.2 | 23.1 | 27.6 | 29.6 | 28.7 | 32.6 | 34.2 | 33.6 | 4.58 |

** Highly significant difference among treatments ($P<0.01$). Untreated group not included in statistical analysis.
[a] A tablet supplying 292 mg. iron, 21.6 mg. copper sulfate, and 2.85 mg. cobalt sulfate given at 3–4 and at 10 days of age to supply a total of 584 mg. iron.
[b] Intramuscular injection of 2 ml. iron-dextran at 3 days of age to supply 100 mg. iron.
[c] Intramuscular injection of 2 ml. iron-dextran at 3 days and 10 days of age to supply a total of 200 mg. iron.

tion of iron tablets was not entirely satisfactory was further evidenced by the fact that undissolved tablets were coughed up in several cases.

The results of trial 3 are summarized in table 3. Only intial and final weights and hemoglobin values were used in analysis of data. Growth was similar in all groups. Hemoglobin values leveled off and, in general, stabilized by the end of the second week in all treatment groups. No symptoms of iron toxicity were noted, even in pigs given the highest level of iron. Normal, healthy pigs are apparently able to tolerate large amounts of iron-dextran without ill effects as measured by growth and hemoglobin.

TABLE 3. LEVELS OF INJECTABLE IRON

| Item | Amount of iron[a] | | | | Standard deviation |
|---|---|---|---|---|---|
| | 100 mg. | 200 mg. | 400 mg. | 1000 mg. | |
| No. of pigs | 5 | 5 | 5[b] | 2 | .... |
| Av. initial weight, lb.[c] | 5.6 | 5.3 | 5.6 | 6.5 | .... |
| Av. final weight, lb.[d] | 17.4 | 17.7 | 18.0 | 18.9 | .... |
| Av. gain per pig, lb. | 11.8 | 12.4 | 12.4 | 12.4 | 1.67 |
| Av. initial hemoglobin, gm./100 ml. | 7.83 | 8.02 | 7.62 | 8.41 | .... |
| Av. final hemoglobin, gm./100 ml.[d] ** | 9.38 | 11.69 | 11.59 | 13.58 | 0.73 |

** Highly significant difference among treatments ($P<0.01$).

[a] All pigs received a single injection, except those receiving 1000 mg. of iron. These pigs received 500 mg. (10 cc.) in each of two separate injections given one week apart.

[b] One pig developed swollen joints and was not included in the data. Post mortem examination revealed no iron toxicity symptoms.

[c] Two litters represented, one litter 3 days and the other 7 days old, initially.

[d] 28 days after iron injection.

## Summary

In these trials, 268 suckling pigs raised in concrete dry lot were used to compare methods and levels of iron administration. Intramuscular injection of 100 mg. (2 ml.) iron at 3 days and again at 10 days of age produced 24-day weights, hemoglobin and hematocrit levels equal to those of pigs whose dam's udders were sprayed daily with a ferrous sulfate solution. A single injection of 100 mg. iron at 3 days of age produced significantly lower hemoglobin ($P<0.01$) and hematocrit ($P<0.05$) than two injections (200 mg.). There were no significant differences among treatments in growth rate.

Oral tablets given at 3 days and 10 days of age to supply a total of 584 mg. iron produced significantly lower hemoglobin ($P<0.01$) and hematocrit ($P<0.01$) at 24 days of age than 100 mg. iron given intramuscularly at 3 days of age. While differences in growth rate were not statistically significant, scouring and general anemic appearance of pigs given oral iron tablets were noticeable. No toxic symptoms were noted in

pigs receiving 200, 400, or 1,000 mg. of iron-dextran intramuscularly. There were no sex differences in any of the criteria measured.

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# MODE OF ACTION OF ANTIBIOTICS IN THE NUTRITION OF THE DAIRY CALF. III. RELATIVE EFFECT OF AGE, COLOSTRUM, AND CHLORTETRACYCLINE FEEDING ON SUSCEPTIBILITY OF INTESTINAL COLIFORM BACTERIA TO PHAGOCYTOSIS [1]

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IN a previous study at this station on the mode of action of antibiotics in nutrition, Radisson *et al.* (1956) demonstrated that feeding low levels of chlortetracycline [2] caused intestinal bacteria in calves to become more susceptible to the host defense mechanism of phagocytosis. These workers postulated, therefore, that chlortetracycline aided the host defense mechanism which accounted for at least a part of the growth response.

Since the growth response to low levels of antibiotics occurs early in the growth cycle and wanes long before growth has been completed (Braude *et al.*, 1953; Lassiter, 1955), it appeared that relationships might exist among age of calf, development of its defense mechanism, and growth response to antibiotic feeding. The first experiment of this study was conducted to study alterations, associated with age and antibiotic feeding, in the host defense mechanism of phagocytosis against intestinal coliform bacteria. Coliform bacteria were chosen for study because organisms in this group have been shown to cause white scours (Dunne *et al.*, 1956).

The importance of colostric antibodies in the ration of calves is well known (Smith *et al.*, 1948). At birth calves must adjust from the sterile *in utero* environment to a nonsterile environment complicated by unnatural congestion in barns. Also, the newborn calf depends on its dam's colostrum for most of its defense against microbes. Thus, it was considered that a clearer picture of the role played by antibiotics in aiding the host defense mechanism would become apparent, if the effects of colostric antibodies were removed. Therefore, the second experiment was carried out to investigate the effectiveness of chlortetracycline in aiding the host defense mechanism of phagocytosis in the presence, and in the absence, of colostrum.

## Materials and Methods

*Experimental Design, Feeding, and Management.* Experiment I: Twenty-four newborn Ayrshire, Guernsey, Holstein and Jersey calves were used in a randomized block design, with six replications of four treatments.

[1] Contribution No. 270, Department of Dairy Husbandry, Kansas Agricultural Experiment Station, Manhattan. Supported in part by a grant from American Cyanamid Co., New York, N. Y. Portion of a dissertation presented by the senior author as partial fulfillment of the requirements for the degree of Doctor of Philosophy in Animal Nutrition at Kansas State College.

[2] The trade name of American Cyanamid Co. for chlortetracycline is Aureomycin.

Four calves of the same sex, breed, and approximate age constituted each block. Treatments were as follows: Group 1, (control), basal ration without chlortetracycline; Group 2, basal ration plus 50 mg. of chlortetracycline per day from birth through 10 weeks of age; Group 3, basal ration for the first 3 weeks, and basal ration plus 50 mg. of chlortetracycline per day from 4 through 10 weeks of age; Group 4, basal ration plus 250 mg. of chlortetracycline per day from birth through 10 weeks of age. The chlortetracycline was fed once daily by capsule. Colostrum was provided by permitting the calves to remain with their dams the first 3 days following birth. Then the calves were placed in individual pens in a calf barn and fed 350 lb. of whole milk over a 6- to 8-week period. When the calves were 1 week old, calf starter ration was placed before them. The starter was fed *ad libitum* until calves of the light breeds were consuming 4 lb. per day and calves of the heavy breeds, 5 lb. per day. The protein content of the starter ration was approximately 22%, and the total digestible nutrients (TDN) 72%. Good quality, chopped alfalfa hay was fed *ad libitum* beginning at 1 week of age. Daily records were kept on the quantities of feed consumed and refused.

When a calf became ill, it was treated by a member of the college veterinary staff. When the illness was severe, the calf was removed from the experiment. The calves were weighed at weekly intervals. Fecal collections for the isolation of coliform bacteria were made during the 1st, 3rd, 5th, 7th, 9th, and 11th weeks. The experiment was terminated for each individual after its last fecal collection.

Experiment II: Sixteen Ayrshire, Guernsey, Holstein and Jersey bull calves were used in randomized block design, with four replications of four treatments. At birth the calves were assigned at random to one of the following treatments: Group O, no colostrum and no chlortetracycline; Group A, 250 mg. of chlortetracycline daily by capsule but no colostrum; Group C, colostrum from the dam for the first 3 days of life but no chlortetracycline; Group AC, 250 mg. of chlortetracycline daily by capsule and colostrum for the first 3 days of life. Feeding and management practices in Experiment II were similar to those in Experiment I with these exceptions: calves were removed from their dams before having had a chance to nurse; when calves became ill with scours, no treatment other than that imposed by the experiment was given; calves that died of scours were examined immediately following death for the presence of microorganisms in the blood obtained from the heart. The experiment was terminated for each living calf at the end of the 7th week.

*Isolation of the Bacteria.* Fecal samples were collected from the colon of each calf by means of a sterile swab or rubber glove and placed in sterile dilution bottles containing 20 ml. of sterile water. The bottles were shaken to disperse the feces and allowed to stand for several minutes so the larger particulate matter could settle. A loopful of the feces-water mixture was transferred to Bacto-Levine Eosin Methylene Blue Agar

(E.M.B.) for the isolation of members of the coliform group of bacteria. From the E.M.B. plates, typical colonies of coliform bacteria were chosen and transferred to nutrient broth.

*Preparation of the Bacterial Suspension.* Normal growth curves for the bacteria were determined with a Bausch and Lomb colorimeter. It was found that after 4 hours of incubation the bacteria were well into the logarithmic growth phase, but not yet into the stationary phase. Since bacteria exhibit their greatest stability during the logarithmic growth phase (Workman and Wilson, 1951), the organisms were incubated at 39° C. for 4 hours prior to use in the experiment. Following this incubation period the cells were washed in sterile, physiological saline.

The bacterial suspension was standardized by diluting with saline to a concentration of $3 \times 10^8$ cells per ml. with a photometer. McFarland Nephelometer tube #1, which has a turbidity approximately equal to a bacterial suspension of $3 \times 10^8$ cells per ml., was used as a standard.

All bacterial suspensions were prepared 4 to 6 hours before they were used.

*Preparation of the Leucocytic Suspension.* Blood for the source of phagocytes was withdrawn from the jugular vein of a healthy two-month-old calf which had not received any antibotic previously. One hundred ml. of blood was withdrawn into a sterile dilution bottle containing: 1.2 gm. of ammonium oxalate and 0.8 gm. of potassium oxalate as an anticoagulant; 0.8 gm. of high molecular weight dextran for increasing the sedimentation rate of the erythrocytes (Radisson *et al.*, 1956); and 0.3 gm. of anhydrous glucose as a source of nutrient for the corpuscles. The leucocytes were separated from the red blood cells by centrifuging whole blood for 10 minutes at 3,000 r.p.m. (1800 gravity) and carefully removing with a Wintrobe blood pipette the leucocytes from where they lay in a grayish layer on top of the red cells. White blood cells were adjusted to a concentration of 40,000 cells per $mm.^3$ with blood plasma by employing a hemocytometer.

*Phagocytic Index.* The procedure for determining the phagocytic index was essentially that of Munoz and Geister (1950) and Radisson *et al.* (1956) with certain modifications. The washed bacterial and leucocytic cells were held separately in a water bath at 39° C. for 30 minutes before bringing them in contact with each other. Then, 0.6 ml. of the leucocytic suspension was pipetted into a 5 ml. tube containing 0.4 ml. of the bacterial suspension. The mixed leucocytic-bacterial suspension was kept in a water bath at 39° C. for 30 minutes, and the tubes shaken gently every 5 minutes.

Slides were prepared by transferring a drop of the leucocytic-bacterial suspension to the slide, preparing a smear, drying the smear quickly in air, and staining lightly with Wright's stain. Microscopic counts were made of the number of bacteria engulfed per 100 phagocytes on each slide, and the resulting number was divided by 100, giving the average number of bacteria

engulfed per phagocyte, or what has been commonly designated "the phagocytic index".

## Results

Experiment I: Through the first 10 weeks after birth the rate of gain of the calves in Group 4 receiving a high level of chlortetracycline was significantly greater (5% level) than the rates of gain of calves in Groups 1, 2, or 3 (table 1). The rates of gain of calves in Groups 2 or 3 were not

TABLE 1. EFFECTS OF DIFFERENT LEVELS AND TIME OF FEEDING CHLORTETRACYCLINE ON GROWTH RATE AND EFFICIENCY OF GAIN OF CALVES

| Group | Amount of chlortetracycline fed/calf/day | No. of calves | 10th wk. wt. in % of birth wt. | | Lb. TDN per lb. of gain | |
|---|---|---|---|---|---|---|
| 1 | None (Control) | 6 | 173 | | 2.55 | |
| | | | | ns | | ns |
| 2 | 50 mg. from 0 through 10 wk. | 6 | 191 | ns | 2.19 | |
| | | | | | | * |
| 3 | 50 mg. from 4 through 10 wk. | 6 | 192 | | 2.21 | |
| | | | | * | | ns |
| 4 | 250 mg. from 0 through 10 wk. | 6 | 216 | | 1.83 | |

ns Nonsignificant.
* Significant at the 5% level.

significantly greater than the rate of Group 1, although the differences approached significance.

The pounds of TDN consumed per pound of gain was significantly less in the treated animals (data were analyzed collectively) than in the controls. When the means were arrayed as in table 1 and the l.s.d. computed, it was found that the mean of Group 4 was significantly less than the mean of Group 1. No significant differences were apparent among other combinations of the means.

The effects of chlortetracycline on the susceptibility of intestinal bacteria to phagocytosis are presented in table 2. Bacteria from calves receiving the 250 mg. level of chlortetracycline had a greater sensitivity to phagocytosis than the control animals during all weeks studied except the 11th. In most instances these differences were statistically significant. Differences in the susceptibility of bacteria to phagocytosis between the calves receiving the lower level of chlortetracycline (Group 2) and the control

(E.M.B.) for the isolation of members of the coliform group of bacteria. From the E.M.B. plates, typical colonies of coliform bacteria were chosen and transferred to nutrient broth.

*Preparation of the Bacterial Suspension.* Normal growth curves for the bacteria were determined with a Bausch and Lomb colorimeter. It was found that after 4 hours of incubation the bacteria were well into the logarithmic growth phase, but not yet into the stationary phase. Since bacteria exhibit their greatest stability during the logarithmic growth phase (Workman and Wilson, 1951), the organisms were incubated at 39° C. for 4 hours prior to use in the experiment. Following this incubation period the cells were washed in sterile, physiological saline.

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TABLE 2. THE RELATIONSHIP OF AGE OF CALVES AND CHLORTETRACYCLINE FEEDING TO THE DEVELOPMENT OF THE CALVES' DEFENSE MECHANISM AS MEASURED BY THE SUSCEPTIBILITY OF INTESTINAL COLIFORM BACTERIA TO PHAGOCYTOSIS

| Group | Amount of Chlortetracycline fed/calf/day | Av. phagocytic index: Age in weeks 1 | 3 | 5 | 7 | 9 | 11 |
|---|---|---|---|---|---|---|---|
| 1 | None (control) | 1.59 | 2.53 | 2.64 | 3.59 | 3.46 | 3.75 |
| 2 | 50 mg. from 0 through 10 wk. | 1.28 | 2.37 | 4.07 | 2.76 | 5.21 | 4.18 |
| 3 | 50 mg. from 4 through 10 wk. | 0.86 | 1.38 | 3.99 | 4.16 | 3.97 | 4.21 |
| 4 | 250 mg. from 0 through 10 wk. | 2.05 | 3.30 | 3.83 | 4.30 | 3.59 | 3.47 |

as Approaching significance.
ns Nonsignificant.
* Significant at the 5% level.

animals were not so clear cut. Average phagocytic indexes (Group 3) were always greater than those of the control during the period of chlortetracycline supplementation (4th to 11th weeks).

By arranging the averages of the data from table 2 in order of progressive weeks, 1st to 11th, a significant difference between weeks was

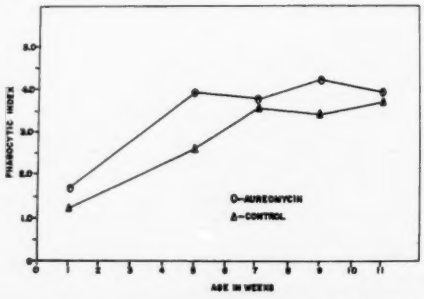


**Figure 1. Average phagocytic indexes for groups of calves receiving chlortetracycline and the group that received none (Experiment I).**

found. When the data were grouped by treatments and graphed (figure 1), the phagocytic index of the supplemented animals increased more rapidly than those of the control animals.

Experiment II: All the calves in Group O died within one week. Their symptoms were those of white scours, characterized by whitish-yellow and fetid feces, listlessness, feed refusal, and prostration. Three of the calves in Group O which were examined at the time of death showed coliform

TABLE 3. THE RELATIONSHIP OF CHLORTETRACYCLINE FEEDING, WITH AND WITHOUT COLOSTRUM, TO THE DEVELOPMENT OF CALVES' DEFENSE MECHANISM AS MEASURED BY THE SUSCEPTIBILITY OF INTESTINAL COLIFORM BACTERIA TO PHAGOCYTOSIS

| Group | Amount chlortetracycline fed/calf/day | Av. phagocytic index: Age in weeks 1 | 3 | 5 | 7 |
|---|---|---|---|---|---|
| O | No chlortetracycline No colostrum | 4.22 | .... | .... | .... |
| | | ns | | | |
| A | 250 mg. chlortetracycline No colostrum | 4.33 | 3.62 | 6.59 | .... |
| | | ** | * | ** | |
| C | No chlortetracycline Colostrum | 1.61 | 2.67 | 4.38 | 5.16 |
| | | ns | * | ** | ** |
| AC | 250 mg. chlortetracycline Colostrum | 1.61 | 5.56 | 8.12 | 8.86 |

ns Nonsignificant.
* Significant at the 5% level.
** Significant at the 1% level.

bacteremia. The fourth calf in Group O died at night, and was not examined.

Two calves in Group A died within a few days after they were born. These calves had symptoms of white diarrhea and coliform bacteria were isolated from the heart blood of one of the calves, but the other had no signs of bacteremia. Another calf in Group A died at 5 weeks of age. The cause of death was not determined, but the heart blood was sterile; no diarrhea was apparent. One calf in Group C died 10 days following birth with symptoms of white scours. Because of the large number of deaths that occurred, a statistical analysis of the growth and feed consumption data was not made.

During the 1st week the mean phagocytic indexes of the calves in Groups

O and A, neither of which had received colostrum, were larger than the mean phagocytic indexes of calves in Groups C and AC, which had received colostrum (table 3). The phagocytic indexes for calves in Groups O and A were higher than those found for calves of this age in the previous trial. Values for Groups C and AC were similar to the values found for one-week-old calves in Experiment I. No real difference was due to chlortetracycline feeding in the 1st week, which was also the case in Experiment I.

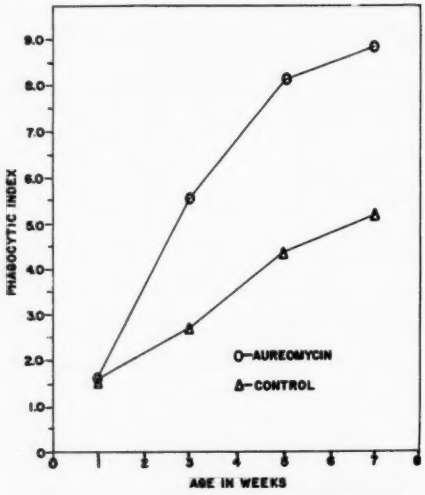


**Figure 2. Average phagocytic indexes for groups of calves receiving chlortetracycline and groups receiving none (Experiment II).**

By the 3rd week all calves in Group O, two in Group A, and one in Group C had died. An analysis of the data during the 3rd and 5th weeks showed a significant increase in the phagocytic indexes due to chlortetracycline feeding (table 3).

In the 7th week (table 3), only the phagocytic indexes for calves in Groups C and AC were analyzed because another calf in Group A had died. The analysis of the data indicated a highly significant difference (1% level) due to chlortetracycline feeding.

Data on phagocytic indexes were grouped according to chlortetracycline-fed and nonsupplemented animals. When these data were graphed (figure 2), as in Experiment I, it was apparent that the same pattern existed between the two sets of data. The values for the control animals climbed steadily for the entire trial (7 weeks). Phagocytic indexes for

the treated animals increased more rapidly than those of control animals, and by the 5th week, the phagocytic index for the treated calves began to level.

*Discussion*

The growth response to chlortetracycline (Experiment I) closely approximated what has been previously reported by other workers (Bartley *et al.*, 1954; Lassiter, 1955), except for the performance of calves in Group 2. One calf in this group suffered with a respiratory disorder throughout the trial, and responded poorly to treatment.

In Experiment I, it was apparent that the host defense mechanism of phagocytosis increased with age rather steadily to 7 weeks. Feeding chlortetracycline aided the host defense mechanism so that nearly maximum phagocytic activity against intestinal coliform bacteria was reached by the 5th week of age. This is the same period of the growth cycle in which antibiotics have been found to be most effective (Bartley *et al.*, 1954; Lassiter, 1955) and deaths due to scours and pneumonia are most prevalent in calves. These data indicate that a rise in the phagocytic index in the first few weeks of the calf's life is important. Thus, the growth performance of calves in Group 4 was superior to those in Groups 1, 2, and 3. These results are in harmony with those of Radisson *et al.* (1956) who observed that bacteria isolated from feces of calves receiving chlortetracycline were more sensitive to phagocytosis than bacteria isolated from feces of calves receiving none.

Phagocytic indexes were higher in value during Experiment II than during Experiment I. Because of the nature of the second experiment, scours were prevalent in all treatments except AC; thus, due to the high incidence of infection, the stimulation of the defense mechanism was maximum. Even though it has been thought that newborn calves lack the ability to produce an immunological response (Smith, 1948), Pierce (1955) has demonstrated that young calves may produce a response. The present data indicate that newborn calves may respond appreciably under proper stimulus, but the response may be too slow to be effective, since it occurred when the disease was severe and failed to prevent death in unprotected calves.

From the results obtained in Experiment II, feeding chlortetracycline to calves enhanced the defense mechanism whether or not the calves were fed colostrum. The response was greatest when both colostrum and chlortetracycline were fed. Chlortetracycline feeding also increased the survival of calves deprived of colostrum, which agrees with the findings of Ingram *et al.* (1958).

It was concluded that since the phagocytic cells employed were from a common source irrespective of treatment, then the changes observed in the susceptibility to phagocytosis of the coliform bacteria from the control

animals were considered to reflect the normal host defense mechanism. Also, the significant increase in susceptibility toward phagocytosis of the coliform bacteria from the animals fed chlortetracycline was considered to be a result of an alteration in the virulence of these microbes as a result of their contact with the antibiotic in the gut of the treated calves. Further, since the reduction in virulence, as measured by increased susceptibility of the bacteria to phagocytosis, so closely followed the improved growth response and feed efficiency, it was postulated that the improved rate of growth and feed efficiency is at least in part a result of the effect of the antibiotic on the intestinal flora.

## Summary

Coliform bacteria were isolated from the feces of chlortetracycline-fed and control calves. The ability of these microbes to resist the defense mechanisms of phagocytosis was measured *in vitro*.

Bacteria isolated from the feces of chlortetracycline-fed calves were more susceptible to phagocytosis than bacteria from unsupplemented animals. Thus, a possible mode of action of antibiotics may be that of affecting intestinal bacteria in such a manner as to make them more susceptible to the body defense mechanism of phagocytosis.

In a second experiment a study was made of the effectiveness of chlortetracycline in aiding the calf's defenses against intestinal coliforms when the passive immunity afforded by colostrum was absent. The phagocytic technique indicated that young calves deprived of colostrum were able to reduce the virulence of coliform bacteria, but the response apparently developed too late as all calves deprived of colostrum died. Feeding chlortetracycline increased the survival of calves that did not receive colostrum. However, the greatest rate of survival and highest mean phagocytic index occurred in the calves receiving both colostrum and chlortetracycline.

In the first and second experiments the mean phagocytic index for the antibiotic-fed calves increased faster and reached a maximum at an earlier age than the mean phagocytic index for the calves fed no chlortetracycline.

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# ENVIRONMENTAL FACTORS IN THE INDUCTION OF ESTRUS IN SHEEP [1]

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FOLLOWING Marshall's (1937) observation that the transportation of sheep and deer from one hemisphere to another resulted in a reversal of the normal seasonal breeding pattern, it was hypothesized that the initiation of the breeding season in sheep is associated with a reduction in day length. Bissonnette (1936, 1941) showed that certain mammals, including the goat, may be brought into estrus by a reduction in day length. This was later demonstrated in sheep by Sykes and Cole (1944), Yeates (1949), Hart (1950) and others, and is the subject of a review by Yeates (1954). Yeates holds the view that high environmental temperatures have no effect on the incidence of estrus, although temperature may effect embryonic development.

It seems clear that high environmental temperatures do affect fertility in rams (Phillips and McKenzie, 1934; McKenzie and Berliner, 1937; Gunn *et al.*, 1942). Dutt and Bush (1955) have induced estrus by the maintenance of environmental temperatures of 45° to 48° F. from May 26 to October 8 in ewes kept under normal light conditions. The sheep came in heat 8 weeks earlier than those kept under similar light conditions but without cooling.

The present experiments were carried out further to investigate environmental factors in the induction of estrus in sheep.

## Experimental Procedure

Four experiments involving 158 ewes were conducted. With the exception of 10 purebred Southdown and 5 purebred Hampshire ewes, the sheep were western ewes of mixed Rambouillet, Hampshire and Suffolk breeding. All animals were fed a ration of alfalfa hay, shelled yellow corn, whole oats and protein supplement. The control animals in each experiment were kept in an open shed under normal light and temperature conditions. The experimental animals were confined in two light-tight rooms each 13 ft. x 12 ft. The walls were insulated with 3 in. of glass wool and the ceiling with hay in a loft above the rooms. The rooms were ventilated with a 16-in. exhaust fan and cooled by two, one-ton capacity air conditioning units. One 200-watt frosted incandescent bulb in a white reflector was located in

[1] Contribution from the Department of Animal Science, the School of Mechanical Engineering and the Purdue Center for Refrigeration Research and Climate Control, Journal Paper No. 1454.

[2] The air conditioning equipment was generously furnished by the International Harvester Company.

the center of the ceiling 10 ft. above the floor of each stall. Light intensity was measured with a model 756 Weston illumination meter. The maximum light intensity 24 in. above the floor in the center of the stall was 9 foot-candles. The maximum intensity in the corners of the stalls was between 4 and 5 foot-candles.

Two systems of lighting were used. In some experiments the sheep were maintained out of doors under natural light conditions and confined to the stalls for specific dark periods. In some experiments the ewes were maintained in the stalls continuously and exposed to controlled amounts of artificial light.

All ewes were observed for estrus each night and morning by using purebred Hampshire and Southdown rams, and were mated whenever found to be in heat. As will be indicated later, in some experiments all rams were kept under normal light and temperature conditions and in some cases were kept under the same conditions as the ewes. No observations were made of semen quality, but as will be indicated later, it appears obvious that the rams were fertile.

The refrigeration equipment available was not designed to maintain a constant temperature, but in general in the stalls occupied by sheep the temperature fluctuated between 70° and 80° F.

## Results and Discussion

*Experiment I.* As shown in table 1, 40 ewes were studied during the early part of the breeding season, July 27 to September 9, in an attempt to induce estrus by a reduction in normal day length. The time from sunrise to sunset was approximately 14½ hr. on July 27, and 12¾ hr. on September 9. All ewes were kept outdoors during the day and those in groups II, III and IV were kept in air-conditioned stalls for a specified dark period.

The occurrence of estrus, length of the estrual cycle, and time of mating resulting in a normal pregnancy are summarized in figure 1. Eight of the 10 control ewes exhibited estrus between July 27 and September 9, as did each of the 20 western ewes in groups II and III in which day length was reduced to either 11 or 10½ hr. There was a total of 9 estrual periods in group I, 22 in group II and 17 and 2 in groups III and IV, respectively.

While there is a suggestion that estrus was induced by the light treatment in group II, and possibly in group III, it is evident that the early

TABLE 1. DESIGN OF EXPERIMENT I

| Group | No. ewes | Breed | Treatment |
|---|---|---|---|
| I | 10 | Western | Normal daylight July 27–Sept. 9 |
| II | 10 | Western | 11 hr. normal daylight July 27–Sept. 9 |
| III | 10 | Western | 11 hr. normal daylight to Aug. 18, then 10½ hr. |
| IV | 10 | Southdown | 11 hr. normal daylight to Aug. 18, then 10½ hr. |

establishment of normal pregnancy was not accomplished. Of those ewes which conceived, the average conception date in the controls was August 28, in comparison with August 31, September 2, and August 28 in groups II, III, and IV, respectively. The ewes in groups I, II, and III were allowed to mate with two Hampshire rams and those in group IV with a Southdown ram. Since two ewes conceived as early as August 13, and six

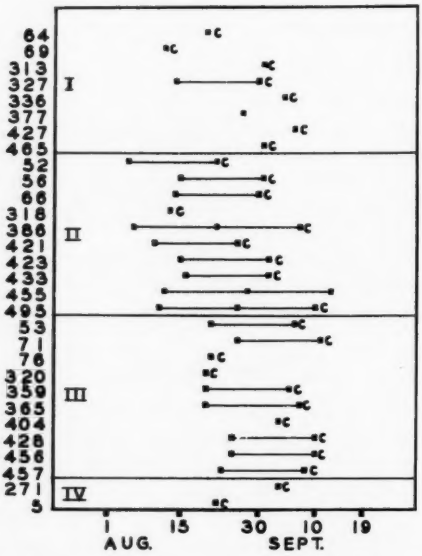


**Figure 1. The occurrence of estrus in Experiment I. C indicates a conception followed by the birth of a lamb.**

had become pregnant by August 23, it does not appear that the ram was an important factor in this study. This is further borne out by the fact that 12 of 28 ewes conceived on the first service. The average length of the estrual cycle in those sheep which did not become pregnant when first mated was 16.0, 16.2 and 16.3 days in groups I, II and III respectively; and it must be concluded that cycle length was normal. If the onset of estrus was significantly hastened in groups II and III, it is obvious that normal fertility was not induced. No explanation for the failure of 8 of the 10 purebred Southdown ewes to come in heat prior to September 9 is offered, since the Purdue Southdown flock is usually bred in late August and September.

*Experiment II.* Thirty-eight yearling western ewes were studied between

TABLE 2. DESIGN OF EXPERIMENT II

| Group | No. ewes | Treatment |
|---|---|---|
| I | 9 | Normal daylight March 22–July 12 |
| II | 9 | 10 hr. normal daylight |
| III | 10 | 10 hr. normal daylight; progesterone Apr. 26, 27, 28 |
| IV | 10 | Two long dark periods, two short light periods each 24 hr. |

March 22 and July 12. As shown in table 2, the control group (I) was maintained in an open shed under normal environmental conditions. Day length (sunrise-sunset) was 12 hr. and 10 min. on March 22; it increased to 15 hr. on June 19, and was 10 min. less than 15 hr. on July 12.

The sheep in groups II and III were kept in air cooled stalls from 5 p.m. to 7 a.m. daily and received 10 hr. of natural daylight. In addition, each ewe in group III was injected with 15 mg. of progesterone in corn oil daily on April 26, 27 and 28. Group IV was kept in air-cooled stalls from 7 a.m. to 5 p.m. and out-of-doors each night. This resulted in two long dark periods, one of a fixed 10-hr. length, and the other which decreased in length as the sunrise-sunset interval lengthened. On March 22, the two dark periods were 10 and 11.75 hr. and the morning and evening light periods 1.25 and 1.0 hr. On July 12 the two dark periods were 10 and 9.25 hr. and the morning and evening light periods 2.5 and 2.25 hr. The ewes were checked for estrus twice daily with Hampshire rams and mated whenever found to be in heat.

None of the ewes in the control group under normal environmental conditions showed any evidences of estrus. Ten of the 19 ewes exposed to 10 hr. of normal daylight came in heat, as did two of the ewes which received two short light periods each 24 hr. Because of Dutt's (1953) success in the induction of estrus in anestrual ewes with progesterone, it was decided to supplement the light treatment with this hormone. Progesterone was injected on April 26, 27 and 28. As shown in figure 2 progesterone

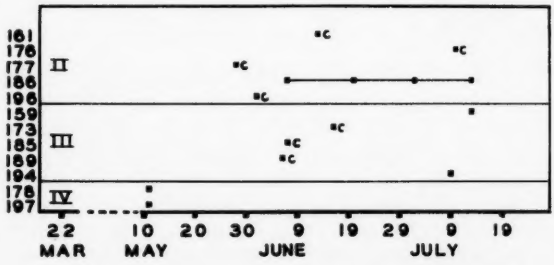


Figure 2. The occurrence of estrus in Experiment II. C indicates conception.

did not hasten the onset of estrus, and there was no difference between groups II and III in the number of sheep which came in heat. It is concluded that progesterone was without effect in this trial.

Two ewes in group IV came in heat on May 11, 50 days after the beginning of the light treatment. Neither conceived, and no more heat periods were observed. This might be explained on the basis that although there were two long dark periods each 24 hr., the short light periods did increase in length from March 22 until July 12. The total daily light on March 22 was 2.25 hr. and on July 12, 4.75 hr. This may have had an

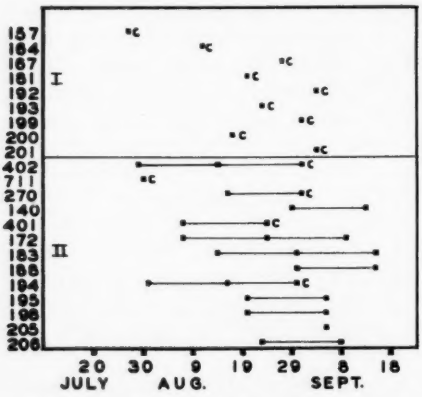


**Figure 3. The occurrence of estrus in Experiment III. C indicates conception.**

inhibiting effect on pituitary function. In groups II and III the first ewe was in estrus on May 28, 67 days after the beginning of the experiment. Seven of the 10 ewes which came in heat in these two groups conceived during the first induced estrus. It can be concluded that out-of-season estrus was induced in half of the ewes receiving 10 hr. of normal daylight, and that fertilization followed by the birth of normal young occurred in 7 of 10 estrual ewes.

*Experiment III.* The objective of this experiment was the same as Experiment I, the induction of estrus in the early part of the normal breeding season. Twenty western ewes were maintained in an open shed as a control group and 15 western and 5 Hampshire ewes were maintained in air-cooled rooms from July 15 to September 17. They were given 10 hr. of artificial light and 14 hr. of darkness each 24 hr. Hampshire rams were allowed to run with each group of ewes, the rams being kept under the same conditions as the ewes.

The data on estrual periods and conception rate are presented in figure 3. Nine of the control and 13 of the treated ewes came in heat. Al-

though one of the control ewes was in heat on July 27 and conceived on that service, there was a distinct trend toward earlier estrus in the light-controlled group (II). It is equally clear that there was a difference in conception rate of the two groups. Each of the nine control ewes conceived on the first service. In group II only five ewes conceived, and only one of these on the first service. The trial was further complicated by the fact that only one of the western ewes (194) became pregnant. There is no reason to believe that the western ewes in group II were different than those in group I. Two Hampshire rams were kept with the ewes in group II, and as shown in figure 3 there was a fertile mating on July 30. As in Experiment I, a reduction in day length during the early part of the breeding season did hasten the onset of estrus with estrual cycles of normal length, but the conception rate was extremely low.

*Experiment IV*. As shown in table 3 a total of 39 yearling and 2-year-old

TABLE 3. DESIGN OF EXPERIMENT IV

| Group | No. ewes | Breed | Treatment |
|---|---|---|---|
| I | 10 | Yrl. western | Normal daylight Mar. 15–July 15 |
| II | 9 | Two-yr. western | Normal daylight Mar. 15–July 15 |
| III | 10 | Yrl. western | 10 hr. normal daylight |
| IV | 10 | Two-yr. western | 10 hr. normal daylight |

western ewes were studied between March 15 and July 15. All of the 2-year-old ewes had lambed and the lambs had been weaned prior to March 15. Groups I and II were kept in an open shed under normal environmental conditions. The sheep in groups III and IV were kept in light-tight rooms from 5 p.m. to 7 a.m. each day and received natural light out-of-doors between 7 a.m. and 5 p.m. Hampshire rams were allowed to run with each group and matings were made whenever the ewes were in heat. On June 6, 7 and 8, five ewes were selected at random from each group and injected twice daily with 12.5 mg. of progesterone in corn oil. Thus each treated ewe received 75 mg. of progesterone.

None of the 19 control ewes showed any evidence of estrus. As in Experiment II, the injection of progesterone was without effect in inducing estrus in anestrual ewes. As shown in figure 4, 17 of 20 ewes subjected to a reduction in light came in heat and were mated. The first heat period occurred on June 8, 85 days after the beginning of the experiment and nine of the ewes were in heat prior to June 18. Six of the 17 ewes which came in heat became pregnant and produced lambs. Ten randomly selected ewes received progesterone in groups III and IV; eight of these came in heat and one conceived. While this might suggest that the light-progesterone treatment increased the incidence of estrus, it clearly did not improve the fertility level.

The nature of the seasonal breeding pattern of sheep, and effective

means of inducing estrus, ovulation, fertilization and normal development of the sheep embryo and fetus have concerned sheep producers and scientists for at least 50 years. As reviewed by McKenzie and Terrill (1937). Heape (1899) Marshall (1903) and others believed that an improvement in plane of nutrition (flushing) induced estrus and increased multiple births. Recent work on this same problem by Foote *et al.* (1959) suggests that in yearling ewes the heavier animals produced the largest number of ova, that a 3-week flushing period increased ovulation rate during one of three years and that full feeding was detrimental to embryo survival

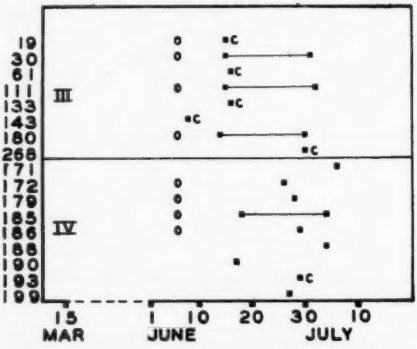


**Figure 4. The occurrence of estrus in Experiment IV. C indicates conception. O Indicates the time of progesterone administration.**

during one of three years. It also appeared that embryo survival was greater in Columbia than in Hampshire dams.

After the report of Cole and Miller (1933) on the induction of estrus and ovulation in anestrual ewes, many attempts to regulate out-of-season breeding by hormonal means have been made. Although some reports of apparently successful endocrine regulation have appeared from time to time, in general it has been difficult to synchronize estrus and ovulation; and, overall fertility as measured by actual lamb crop has been discouragingly low.

Yeates (1954) concluded that the most effective means of producing out-of-season lambs is by the control of day length. As mentioned earlier, he feels that high environmental temperatures do not affect estrus in a proper light environment, although embryonic development might be affected by temperature. In view of Dutt's work referred to earlier, it appears that a reduction in ambient temperature may be an effective stimulus in the induction of estrus. As reported by Hulet *et al.* (1956) the seasonal fluctuation in fertility of the ram, the high incidence of un-

fertilized ova prior to September 16, and the occurrence of a nearly 30% embryonic death prior to September 16 are still important barriers to early or out-of-season sheep breeding.

Further work needs to be done in a completely controlled climatic environment in which the relationships of light, temperature, humidity, hormone secretion, and nutrition can be studied independently and in combination.

## Summary

Four experiments involving 158 ewes were conducted. With the exception of 10 Southdown and 5 Hampshire ewes, the sheep were western ewes of mixed Rambouillet, Hampshire and Suffolk breeding.

The reduction of day length to 10 hours during the nonbreeding season from approximately March 15 to July 15 was effective in the induction of estrus. None of 28 ewes in a normal environment came in heat in comparison with 27 of 39 receiving 10 hours of light. However, only 13 of 27 ewes which came in heat during the 10-hr. light treatment produced lambs. It may be concluded that a reduction in day length during anestrum is highly effective in the induction of estrus, but that fertility as measured by actual lambing is low.

The reduction of day length during the early part of the normal breeding season from approximately July 15 to September 17 appeared to hasten the onset of estrus, but satisfactory fertility was not obtained. Of 30 western ewes maintained in a normal environment, 17 came in heat prior to September 17. Thirty-three of 40 ewes subjected to a reduced lighting regime came in estrus, but only 5 of these conceived on the first induced period. Thus, there was little advantage in terms of early lamb production. The role of the ram and the incidence of early embryonic mortality were not investigated.

The administration of progesterone in conjunction with a reduction in day length did not hasten the onset of estrus or improve fertility.

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# EFFECT OF VARYING LEVELS OF FIBER OF DIFFERENT SOURCES UPON GROWTH AND CARCASS CHARACTERISTICS OF SWINE [1, 2]

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IT has been demonstrated that lean pork carcasses can be produced by restricting the energy intake of pigs. Ellis and Zeller (1932, 1934) and Winters *et al.* (1949) reported the production of lean pork carcasses by restricting the energy intake of swine with limited hand-feeding. Similar results have been obtained by replacing part of a high energy ration with fibrous feeds (Crampton *et al.*, 1954; Bohman *et al.*, 1955; Merkel *et al.*, 1958). However, Teague *et al.* (1954) reported that when a cellulose product (Ruffex) replaced corn starch in a purified basal ration at levels of 5, 10, 15 and 20%, carcass characteristics could not be correlated with the level of fibrous material fed. The 15% and 20% levels of Ruffex brought about a decrease in rate of growth and feeding efficiency. Work on utilization of different kinds of fiber indicates that the source of fiber may be a factor in its effects (Bohstedt and Fargo 1933; Forbes and Hamilton, 1952).

The work reported here was carried out by the Michigan Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture. The purpose was to study the effects of various levels of fiber from different sources on feed lot performance and carcass characteristics of swine. Oats, wheat bran and alfalfa meal were used as the fibrous feeds.

## Experimental Procedure

Four feeding trials were conducted with a total of 108 pigs. The breeds represented were Berkshire, Chester White, Duroc and Chester White-Duroc crossbreds from the University herd. The pigs were started on trial after they were weaned and wormed. Of the 27 pigs in each trial 15 were divided into three groups of five and self-fed, and the remaining 12 pigs were self-fed in individual pens. There were three ration treatments with nine pigs per treatment in each trial. Pigs were weighed at 14-day intervals and feed consumption recorded. Daily gain and feed efficiency were cal-

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TABLE 1. BASAL RATIONS FED IN DIFFERENT TRIALS

| Ingredients | Trial 1 | | Trial 2 | | Trial 3 | | Trial 4 | |
|---|---|---|---|---|---|---|---|---|
| | Initial to 100 lb. | 100 lb. to 210 lb. | Initial to 100 lb. | 100 lb. to 210 lb. | Initial to 100 lb. | 100 lb. to 210 lb. | Initial to 100 lb. | 100 lb. to 210 lb. |
| Ground corn, % | 80.0 | 87.0 | 79.0 | 86.0 | 78.1 | 85.0 | 76.3 | 85.2 |
| Protein supplement, % | 17.8[a] | 11.56[a] | 19.3[a] | 12.3[a] | 20.5[b] | 13.6[b] | 22.3[b] | 13.4[b] |
| Dicalcium phospate+zinc,[c] % | 0.69 | 0.44 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 |
| Trace mineral+salt, % | .67 | .44 | .6 | .6 | .5 | .5 | .5 | .5 |
| Limestone, % | .69 | .44 | .6 | .6 | .3 | .3 | .3 | .3 |
| Aurofac 10, % | .05 | .04 | .05 | .05 | .05 | .05 | .05 | .05 |
| Merck vitamin mix #58C, % | .07 | .05 | .05 | .05 | .05 | .05 | .05 | .05 |
| Vitamin A and D[d] | .04 | .03 | .025 | .025 | .025 | .025 | .025 | .025 |

[a] Supplement: Soybean oil meal, 65%; meat and bone scrap, 15%; fishmeal, 5%; and dehydrated alfalfa meal, 15%.

[b] Supplement: Soybean oil meal, 55%; meat and bone scrap, 20%; alfalfa meal, 15%; and wheat middlings, 10%.

[c] Contains 10 gm. of zinc carbonate per pound of dicalcium phosphate.

[d] Contains 10,000 USP units of vitamin A and 3,000 USP units of vitamin D per gm.

culated. All rations were analyzed by A.O.A.C. methods. The constituents of the basal rations are given in table 1. The percentages of protein, crude fiber and estimated TDN are presented in table 2.

All pigs were slaughtered when they reached approximately 210 lb. Each pig was fasted for 24 hours before the live slaughter weight was

TABLE 2. PERCENT OF PROTEIN, CRUDE FIBER AND TDN[a] IN RATIONS

| | Under 100 lb. | | | 100 lb. to slaughter | | |
|---|---|---|---|---|---|---|
| Trial I—Oat rations | Basal | 20% | 40% | Basal | 20% | 40% |
| Protein | 14.9 | 15.2 | 15.2 | 12.9 | 12.8 | 12.6 |
| Crude fiber | 3.1 | 4.5 | 6.5 | 2.9 | 5.0 | 6.3 |
| TDN | 74.47 | 72.23 | 69.98 | 75.55 | 73.42 | 71.24 |
| Trial II—Wheat bran | Basal | 20% | 40% | Basal | 20% | 40% |
| Protein | 14.6 | 14.6 | 14.6 | 13.0 | 13.2 | 13.4 |
| Crude fiber | 3.1 | 4.4 | 5.8 | 2.6 | 3.9 | 5.2 |
| TDN | 74.72 | 70.88 | 66.95 | 75.35 | 71.51 | 67.88 |
| Trial III—Alfalfa meal | Basal | 10% | 20% | Basal | 10% | 20% |
| Protein | 15.0 | 14.9 | 15.0 | 13.1 | 12.7 | 13.0 |
| Crude fiber | 2.8 | 5.5 | 8.2 | 2.5 | 5.2 | 8.1 |
| TDN | 74.81 | 70.92 | 66.68 | 75.26 | 71.32 | 67.10 |
| Trial IV—Wheat bran | Basal | 20% | 40% | Basal | 20% | 40% |
| Protein | 17.8 | 18.7 | 18.0 | 13.2 | 14.5 | 14.2 |
| Crude fiber | 3.5 | 5.2 | 6.3 | 2.8 | 4.2 | 5.3 |
| TDN | 74.62 | 70.70 | 66.75 | 75.40 | 71.48 | 68.48 |

[a] TDN calculated from National Research Council tables.

taken. The following measurements were made on the chilled carcass: dressing percentage, backfat thickness, carcass length, lean cuts (both live and carcass basis), primal cuts (both live and carcass basis), area of *Longissimus dorsi* at the 10th and last rib and percent fat trim. The following visceral weights were taken in Trials 2, 3 and 4: stomach (both full and empty), small intestine and large intestine (both full and empty).

In Trial 1 (Summer, 1955) oats replaced 20% and 40% of the basal ration. Seven Duroc, three Chester White and five Chester White-Duroc crossbred pigs were divided into three groups so that a littermate was on each treatment. Each group contained three barrows and two gilts. These pigs were group fed on a concrete slab with a house at one end. Water and feed were available at all times. In addition, six Chester White and six Chester White-Duroc crossbred pigs were lotted so that a littermate was on each treatment. Three barrows and one gilt were fed each ration. These pigs were placed in individual pens (8′ x 3′) and had access to feed and water at all times.

In Trial 2 wheat bran replaced 20% and 40% of the basal ration (Fall and Winter, 1955–1956). Twenty-four Duroc and three Chester White pigs were used in this trial. The experimental procedure was the same as in the first trial.

In Trial 3 alfalfa meal replaced 10% and 20% of the basal ration (Summer, 1956). Nine Berkshire and 18 Chester White pigs were used in this experiment. The procedure was the same as in the first two trials.

In Trial 4 wheat bran was used as the fibrous feed in the same proportions as in the second trial. Eighteen Duroc and nine Chester White-Duroc crossbred pigs were used. The group-fed pigs were managed in the same manner as in the other trials. Since excessive feed wastage was encountered in the individually fed lots, the feeders were removed from the pens except for three one-hour periods per day (morning, noon and night).

The data obtained from these trials were subjected to analysis of variance (Snedecor, 1956). Duncan's studentized range method (1955) of testing for significant differences between lots was used. Tests for interaction between treatments and methods of feeding (group or individually fed) were made on all data. Feed efficiency differences were calculated from data on the individually fed pigs.

## Results and Discussion

Means and standard deviation of daily gains and feed efficiency for group-fed, individually fed and combined lots are given in table 3; those of the carcass characteristics are presented in table 4. Since there were no interactions between treatment and method of feeding with respect to carcass traits, only the combined (group and individually fed lots) data are given.

*Daily Gains.* Figure 1 shows the effect of rations on daily gains. In the

TABLE 3. MEANS AND STANDARD DEVIATIONS FOR FEED LOT PERFORMANCE

| Ration | Initial weight | Average daily gains | | | Average feed per lb. of gain | | | Final feed lot weight |
|---|---|---|---|---|---|---|---|---|
| | | Group fed[a] | Individually fed[b] | Combined[c] | Group fed[a] | Individually fed[b] | Combined[c] | |
| | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| Trial 1 | | | | | | | | |
| Basal | 41.1 | 1.6±.15 | 1.7±.08 | 1.7±.05 | 3.5 | 3.6±.18 | 3.6 | 209 |
| 20% Oats | 40.6 | 1.6±.08 | 1.6±.13 | 1.6±.04 | 3.5 | 3.6±.11 | 3.5 | 209 |
| 40% Oats | 40.2 | 1.6±.05 | 1.6±.08 | 1.6±.03 | 3.7 | 3.7±.11 | 3.7 | 208 |
| Trial 2 | | | | | | | | |
| Basal | 38.7 | 1.6±.17 | 1.8±.09 | 1.7±.06 | 3.5 | 3.7±.11 | 3.6 | 209 |
| 20% Wheat bran | 39.8 | 1.5±.11 | 1.7±.16 | 1.6±.08 | 3.8 | 4.5±.34* | 4.1 | 207 |
| 40% Wheat bran | 38.9 | 1.4±.04* | 1.4± 08** | 1.4±.02** | 4.0 | 4.6±.17* | 4.3 | 207 |
| Trial 3 | | | | | | | | |
| Basal | 35.1 | 1.4±.13 | 1.5±.31 | 1.4±.08 | 3.5 | 4.0±.68 | 3.7 | 208 |
| 10% Alfalfa meal | 34.9 | 1.3±.09 | 1.4±.19 | 1.3±.05 | 3.8 | 4.3±.33 | 4.0 | 211 |
| 20% Alfalfa meal | 34.8 | 1.2±.15 | 1.3±.21 | 1.2±.06 | 4.4 | 5.3±.17 | 4.8 | 207 |
| Trial 4 | | | | | | | | |
| Basal | 32.0 | 1.6±.13 | 1.5±.08 | 1.6±.04 | 3.4 | 3.5±.06 | 3.5 | 215 |
| 20% Wheat bran | 32.5 | 1.6±.15 | 1.4±.15 | 1.5±.06 | 3.6 | 4.0±.21 | 3.8 | 212 |
| 40% Wheat bran | 32.4 | 1.4±.06* | 1.3±.31 | 1.3±.07* | 4.0 | 4.6±.05** | 4.3 | 210 |

* Significant at 5% level.
** Significant at 1% level.
[a] There were 5 pigs per treatment.
[b] There were 4 pigs per treatment.
[c] There were 9 pigs per treatment.

first trial, the daily gains were very similar regardless of the level of oats in the ration. In the second trial, pigs receiving 40% bran gained at a significantly slower rate ($P<0.01$) than those in the basal lot. When wheat bran was repeated (Trial 4), growth rate of the pigs receiving 40% bran was again significantly lower ($P<0.05$) than that of those in the

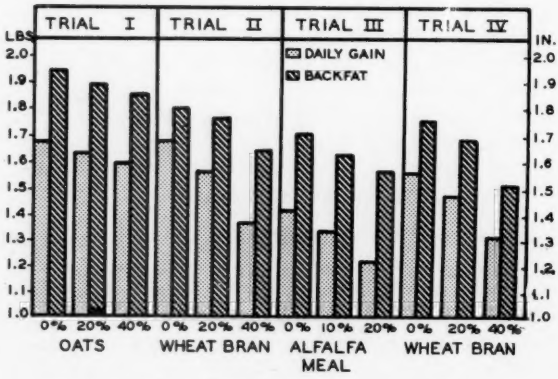


**Figure 1. Effect of fiber on daily gain and backfat.**

TABLE 4. MEANS AND STANDARD DEVIATIONS OF VARIOUS CARCASS CHARACTERISTICS (GROUP AND INDIVIDUALLY FED LOTS COMBINED)

| Ration | Backfat thickness[a] | Carcass length[b] | Dressing percentage | Lean cuts carcass basis[c] | Primal cuts carcass basis[d] | Fat trim |
|---|---|---|---|---|---|---|
| | in. | in. | | % | % | % |
| Trial 1 | | | | | | |
| Basal | 2.0±.08 | 28.8±.26 | 75.8±.46 | 46.9±.70 | 61.1± .59 | 26.3± .89 |
| 20% Oats | 1.9±.03 | 28.8±.19 | 75.3±.32 | 46.6±.67 | 61.4± .53 | 26.7± .42 |
| 40% Oats | 1.9±.06 | 28.1±.39 | 75.9±.66 | 47.0±.92 | 61.4±1.01 | 26.3±1.14 |
| Trial 2 | | | | | | |
| Basal | 1.8±.05 | 28.2±.25 | 75.0±.42 | 48.1±.55 | 61.9± .69 | 28.1± .72 |
| 20% Wheat bran | 1.8±.07 | 27.8±.22 | 74.7±.75 | 48.0±.81 | 62.8± .69 | 26.7± .99 |
| 40% Wheat bran | 1.6±.04 | 28.1±.15 | 74.2±.54 | 49.2±.52 | 64.3± .78 | 26.0± .93 |
| Trial 3 | | | | | | |
| Basal | 1.7±.09 | 28.7±.26 | 74.5±.29 | 50.3±.95 | 64.6± .97 | 25.8± .97 |
| 10% Alfalfa meal | 1.6±.06 | 29.2±.33 | 73.0±.56 | 50.9±.66 | 65.3± .62 | 25.6±1.05 |
| 20% Alfalfa meal | 1.6±.04 | 29.2±.33 | 73.5±.51 | 51.9±.78 | 65.8± .65 | 24.0± .75 |
| Trial 4 | | | | | | |
| Basal | 1.8±.05 | 29.1±.18 | 74.1±.44 | 48.9±.64 | 62.7± .61 | 27.4± .66 |
| 20% Wheat bran | 1.7±.05 | 29.6±.21 | 73.0±.44 | 49.7±.95 | 63.8± .90 | 25.5± .80 |
| 40% Wheat bran | 1.5±.03**[2] | 29.8±.25 | 72.0±.62* | 52.1±.73*[2] | 65.8± .60*[2] | 23.1± .75** |

Nine pigs per treatment

* Significant from basal (P=0.05). *[2] Signficant from both basal and 20% lot (P=0.05).

** Significant from basal (P=0.01). **[2] Significant from both basal and 20% lot (P=0.01).

[a] Average thickness measured at first, seventh and last rib and last lumbar.

[b] Measured from the anterior edge of aitch bone to the anterior edge of the first rib.

[c] Include New York shoulder, loin and ham.

[d] Include New York shoulder, loin, ham and belly.

TABLE 5. MEAN WEIGHTS AND STANDARD DEVIATIONS OF STOMACH, INTESTINES AND CONTENTS

| Item | Trial 2 | | | Trial 3 | | | Trial 4 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Basal | 20% Bran | 40% Bran | Basal | 10% Alfalfa | 20% Alfalfa | Basal | 20% Bran | 40% Bran |
| | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| Wt. of full stomach | 1.6± .13 | 1.7±.37 | 1.9± .37 | 1.5±.22 | 1.6± .26 | 1.7±.28 | 1.8± .38 | 1.8± .21 | 2.1± .11 |
| Wt. of empty stomach | 1.3± .11 | 1.5±.19 | 1.6± .19 | 1.2±.15 | 1.3± .12 | 1.2±.12 | 1.3± .11 | 1.5± .17 | 1.7± .19 |
| Wt. of small intestine | 4.0± .23 | 3.6±.39 | 3.7± .84 | 3.8±.50 | 4.3±1.27 | 4.3±.72 | 4.1± .66 | 4.1± .51 | 4.2± .65 |
| Wt. of full large intestine | 8.2±1.34 | 8.7±.76 | 9.6±1.14* | 6.2±.77 | 7.1±1.88 | 7.2±.98 | 7.2±1.01 | 8.7±1.32 | 9.7±2.51* |
| Wt. of empty large intestine | 5.5±1.02 | 5.1±.69 | 5.4± .95 | 4.1±.98 | 4.0± .50 | 4.3±.60 | 4.2± .91 | 4.7± .44 | 4.8± .73 |
| Fill in large intestine | 2.7±1.06 | 3.6±.83 | 4.2± .75* | 2.1±.65 | 3.1±1.57 | 2.9±.69 | 3.0±1.04 | 4.0±1.12 | 4.9±1.91* |

* Significant at 5% level.

basal lot. A similar trend was exhibited by the pigs on 20% alfalfa meal ration, although the difference was not significant. The highest rate of gain was obtained with the basal rations in all trials.

*Feed Efficiency.* There were no significant differences between treatments in Trial 1 or in Trial 3. In Trial 2, the feed required per pound of gain increased significantly ($P<0.05$) when wheat bran replaced 20% and 40% of the basal ration. When wheat bran was repeated (Trial 4), the 40% bran lot pigs required significantly more ($P<0.01$) feed per pound of gain than the basal lot pigs.

*Carcass Characteristics.* Figure 2 shows the effect that each ration had on the average backfat thickness. There was a trend for carcasses from the 40% bran lot (Trial 2) and the 20% alfalfa meal lot (Trial 3) to have decreased backfat thickness and a lower percent fat trim than those from the basal lots. In Trial 4, carcasses from the 40% bran lot had significantly less thick ($P<0.01$) backfat than those from the basal or 20% bran lots. This effect was accompanied by a lower percent fat trim ($P<0.01$) in the carcasses from the 40% bran lot as compared with those from the basal lot. The percentage of lean and primal cuts was significantly larger ($P<0.05$) in carcasses from the 40% bran lot than in carcasses from either the basal or 20% bran lots. On the other hand, the dressing percentage of pigs from the 40% bran lot (Trial 4) was significantly lower ($P<0.05$) than that of those from the basal lot. There was significantly more fill in the large intestines of pigs from the 40% bran lots than in those of pigs from the basal lots (table 5). Thus, the amount of feed and water retained in the digestive tract appears to contribute to the lower dressing percentage. However, the weights of stomach, small intestine and empty large intestine were not significantly affected by any of the rations.

Carcass length and area of the *Longissmus dorsi* were not measurably affected by the rations.

There was a correlation of 0.48 between rate of gain and backfat thickness, indicating that there is a tendency for the backfat thickness to decrease as the rate of gain is slowed, which is in agreement with Crampton *et al.* (1954). The data indicate that the kind of fibrous feed is a factor in feed lot performance, which supports the work of Forbes and Hamilton (1952). Such carcass characteristics as backfat thickness, percent fat trim, lean and primal cuts also appear to be influenced by the kind of fibrous feed. The above effects may be related to the amount of total digestible nutrients in the ration, since wheat bran and alfalfa meal decreased the TDN more than oats (table 2).

## Summary

Feed lot performance and carcass characteristics were studied with 108 growing-fattening pigs fed a series of rations containing 0, 20 and 40% oats; 0, 20 and 40% wheat bran; and 0, 10 and 20% alfalfa meal. There

were no significant differences in feed lot performance or carcass characteristics between pigs fed rations containing 0, 20 and 40% oats. There was a non-significant decrease in rate of gain and backfat thickness as alfalfa meal was increased in the ration. There was a significant decrease in rate of gain, feed efficiency, dressing percentage and percent of fat trim in pigs fed a ration containing 40% wheat bran. This was accompanied by a similar increase in lean and primal cuts (carcass basis).

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# FEEDING PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING-FINISHING SWINE FED "C" GRADE SUGAR [1]

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SEVERAL investigators have shown that the presence of sugar in the rations of young pigs enhances palatability (McMillan *et al.*, 1954; Lewis *et al.*, 1955; Diaz *et al.*, 1956). In studies involving growing-finishing swine dietary sugar has exerted a beneficial effect on various carcass characteristics (Wilcox *et al.*, 1953).

"C" sugar, the lowest grade of sugar from the standpoint of polarization and freedom from impurities, has been successfully used in the creep rations of pigs at levels ranging from 10% to 40% (Combs *et al.*, 1956). The experiment reported herein was designed to study the effects of including various levels of "C" sugar in the ration of growing-finishing pigs.

## Experimental

Seventy-two weanling pigs of Duroc, Hampshire and Spotted Poland China breeding were divided according to breed, sex and weight into six treatment groups. Treatments 1–5 contained 0, 10, 20, 30 and 40% "C" sugar, respectively. In treatment 6 "C" sugar and a protein supplement

TABLE 1. PERCENTAGE COMPOSITION OF RATIONS AND PROTEIN SUPPLEMENT FED TO PIGS

| Treatment number | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| "C" sugar | 0 | 10 | 20 | 30 | 40 | free choice |
| Ground yellow corn | 83.35 | 71.5 | 59.65 | 47.80 | 36.00 | ..... |
| Soybean oil meal | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 47.0 |
| Tankage | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 47.0 |
| Vitamin A and D mix [a] | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 3.0 |
| Iodized salt | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 1.5 |
| Ground limestone | 0.65 | 0.50 | 0.35 | 0.2 | ... | ... |
| Antibiotic supplement [b] | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.6 |
| B-vitamin supplement [c] | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 |
| Trace minerals [d] | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.6 |

[a] Provided 2380 IU of vitamin A and 396 IU of vitamin D per lb. of feed.
[b] Aurofac-10 contains 10 gm. chlortetracycline per pound.
[c] Fortafeed 2–49C contains the following in mg. per pound: riboflavin, 2000; pantothenic acid, 4000; niacin, 9000; and folic acid, 60.
[d] Trace mineral premix for swine supplied by the Calcium Carbonate Co., Chicago, Illinois.

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were fed free-choice. The composition of the rations and the protein supplement fed are presented in table 1. The "C" sugar was incorporated into the various rations at the expense of corn. A constant quantity of protein, approximately 14%, was maintained by adjusting the amounts of soybean meal and tankage.

All rations were self-fed on dirt lots. As the pigs reached a live-weight of approximately 210 lb. they were weighed, fasted for 24 hours, slaughtered and dressed packer style-leaf fat in. Weekly weights, total feed consumption and various slaughter characteristics were recorded. Liver samples were cooked in an electric oven without seasonings for 30 minutes at 325° F. A panel of seven members evaluated the liver for flavor desirability using a seven point hedonic scale. Refractive indices were obtained on external fat samples with an Abbe refractometer. The data were analyzed according to procedures described by Snedecor (1956) and by Duncan (1955).

## Results and Discussion

A summary of the average performance data and carcass characteristics is presented in table 2. The growth rate of pigs fed sugar and a protein supplement free-choice (treatment 6) was significantly lower than that of pigs on any of the other treatments. This slow rate of growth may be attributed in part to the method of feeding (i.e., free-choice) and/or the quality of protein consumed. Since "C" sugar is essentially nitrogen-free and was used instead of corn as the main source of energy, an amino acid imbalance may have occurred. It appears unlikely that the quantity of protein was a limiting factor since a breakdown of the feed consumed by pigs in treatment 6 showed that their average daily ration was composed of approximately 72% sugar and 28% protein supplement.

While the feed efficiency figures were not adaptable to statistical analysis it is apparent that with the exception of treatment 6, the feed required per pound of gain was comparable in all treatments. The similarity in feed consumption figures for all ration treatments indicates that the presence of sugar does not enhance ration palatability for growing-finishing swine.

The dressing percentage of pigs on treatment 1 was significantly lower than that of pigs on treatments 3 and 5. This difference between treatments 1 and 4 was also relatively large and was found to approach statistical significance. While the methods of feeding sugar were quite different from that used by Wilcox *et al.* (1953), sugar in both instances was found to increase the dressing percentage.

Liver weights of pigs on treatment 6 were significantly higher than those of pigs on any other ration treatment. Previous work by Gibbons and Rose (1950), Wilcox *et al.* (1953) and Greenwood *et al.* (1953) also demonstrated that the feeding of sugar increases the liver weights of pigs. Liver desirability was significantly influenced by the amount of sugar in the ration; livers from pigs fed sugar free-choice (treatment 6) and as 40%

of the ration had the most desirable flavor. The livers from the control pigs were least desirable. Similar findings have been reported by Wilcox *et al.* (1953) and Greenwood *et al.* (1953).

Carcass grade was not found to be significantly influenced by ration treatments. Refractive indices showed that the pigs fed sugar free-choice had softer carcasses than pigs on the other ration treatments. However, it appears doubtful that these soft carcasses can be attributed to the sugar *per se* since the carcasses of pigs that received the 30% and 40% sugar

TABLE 2. SUMMARY OF FEEDING AND SLAUGHTER DATA

| Treatment number | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Number of pigs | 12 | 12 | 11[a] | 12 | 12 | 12 |
| Initial wt., lb. | 54.4 | 51.8 | 50.9 | 55.0 | 55.3 | 54.5 |
| Av. daily gain, lb. | 1.98 | 2.00 | 2.02 | 2.09 | 2.03 | 1.64[b] |
| Av. daily feed, lb. | 6.49 | 6.40 | 6.54 | 6.71 | 6.66 | 6.53 |
| Feed lb. gain, lb. | 3.28 | 3.20 | 3.24 | 3.21 | 3.28 | 3.98 |
| Dressing percentage | 72.4[c] | 72.7 | 74.1 | 73.9 | 74.1 | 73.0 |
| Liver wt., %[h] | 1.56 | 1.51 | 1.63 | 1.65 | 1.64 | 1.92[d] |
| Liver desirability[i] | 5.18 | 5.24 | 5.53 | 5.35 | 5.99[e] | 6.40[e] |
| Carcass grade[j] | 1.66 | 1.58 | 1.91 | 1.75 | 1.66 | 1.50 |
| Refractive indices | 1.4605 | 1.4605 | 1.4600 | 1.4599[f] | 1.4598[f] | 1.4612[d] |
| Percentage lean cuts[k] | 45.37 | 44.62 | 44.64 | 43.90 | 44.84 | 47.43[g] |

[a] Missing data calculated.
[b] Lower than all other treatments ($P<0.01$).
[c] Lower than treatments 3 and 5 ($P<0.05$).
[d] Higher than all other treatments ($P<0.01$).
[e] Higher than treatments 1, 2, 3 and 4 ($P<0.01$).
[f] Lower than treatments 1 and 2 ($P<0.05$).
[g] Higher than all other treatments ($P<0.05$).
[h] $\frac{\text{Liver weight}}{\text{Live weight}} \times 100$.
[i] Number 1 is least desirable; number 7 is most desirable.
[j] U. S. Choice No. 1=1, U. S Choice No. 3=3.
[k] $\frac{\text{Ham, loin, picnic and Boston butt weight}}{\text{Hot carcass weight}} \times 100$.

rations were significantly firmer than the pigs fed 0, 10 or 20%. Rate of gain appears to exert some influence on carcass firmness; the higher daily gains being associated with the firmer carcasses. The percentage lean cuts was highest in the pigs fed sugar free-choice.

From the standpoint of improving rate and/or efficiency of gain the results of this study indicated that a beneficial effect was not obtained by the inclusion of sugar in the ration. While dressing percentage, liver weight and liver flavor were significantly improved in some instances, similar results have been obtained by other workers using a considerably shorter feeding period. However, while it appears that little, if any, advantage is associated with the feeding of sugar to growing-finishing swine for an extended period of time, it is evident that sugar may satisfactorily serve as the major source of energy.

## Summary

Six groups of weanling pigs were fed rations containing various levels of "C" sugar. One group was given sugar free-choice with a protein supplement and the remaining groups were fed sugar at levels of 0, 10, 20, 30 and 40% of the ration.

The pigs fed sugar free-choice gained significantly slower than pigs on any of the other ration treatments and were less efficient in feed conversion. Feed consumption was similar for pigs on all treatments.

The dressing percent of pigs fed the 20% and 40% sugar-containing rations was significantly higher than that of the control pigs. Carcass grade was not significantly affected by ration treatment. Livers from pigs fed sugar free-choice or as 40% of the ration had the most desirable flavor.

The pigs fed sugar free-choice had significantly heavier livers, softer carcasses and a higher percent of lean cuts than pigs fed the other rations.


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# INJECTABLE IRON-DEXTRAN AND SEVERAL ORAL IRON TREATMENTS FOR THE PREVENTION OF IRON-DEFICIENCY ANEMIA OF BABY PIGS [1]

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THE incidence of iron-deficiency anemia in suckling pigs reared in confinement has for years presented a major problem to the swine producer and the researcher. Since McGowan and Crichton (1923) discovered that this anemic condition was caused by an iron deficiency, much time and effort has been expended in developing improved oral methods of administering iron to the suckling pig. However, all these methods and means have had limitations as well as advantages. The major limitation has been the necessity for repeated applications throughout the suckling period. For this reason, field application of iron treatments has seldom been completely satisfactory.

With the development of an injectable iron-dextran complex for human medicine by the English workers London and Twigg in 1952 (McDonald *et al.*, 1955), its application to the swine industry was investigated (McDonald *et al.*, 1955; Barber *et al.*, 1955; Brownlee, 1955; Kernkamp, 1957; Swenson *et al.*, 1957; Ullrey *et al.*, 1957). Favorable results have been obtained with an intramuscular injection of 100 mg. iron during the first week of life. This amount of iron has been found to be sufficient for the first three weeks postpartum.

The purposes of the experiments reported in this paper were: first, to compare the iron-dextran complex with the iron-deficiency anemia treatment regimen that has previously been used at the Iowa Station; second, to compare the parenteral iron treatment with oral iron treatments; and third, to determine the level of iron as iron-dextran necessary for maximum growth, both for pigs weaned at 3 weeks of age and for pigs allowed to nurse to 8 weeks of age.

## Experimental Procedure

*Experiment I.* Growth and hemoglobin observations were made over a five-week lactation period on the litters of 16 crossbred sows. The litters were farrowed in crates and remained there for one week, after which the sows and litters were moved to concrete-floored pens. The sows were

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[3] Animal Husbandry Department.

hand-fed twice daily while in farrowing crates and self-fed in the pens. The sows and pigs had access to water *ad libitum*. The baby pigs were not offered a creep ration, but did have access to the sow's feed. At birth the pigs were randomly allotted to a treatment from outcome groups of birth weight within litter. Two treatments were compared in each litter: (1) a single 2 ml. intramuscular injection of iron-dextran (100 mg. of elemental iron) administered on the second day of life and (2) oral doses of an iron-copper paste (28 mg. of iron as ferrous sulfate and 2 mg. of copper as cupric sulfate) given at 2 days, 1, 2, 3 and 4 weeks of age. The pigs were individually weighed at weekly intervals. Hemoglobin levels were obtained at birth, 18 and 35 days of age from ear-vein blood samples, treated by the acid hematin method and read in a Fisher Electro-Hemometer.

*Experiment II.* This experiment was designed to compare methods of iron administration using 40 litters from crossbred sows. Management and feeding practices were similar to those in Experiment I. Four treatments were compared: (1) a single 2 ml. injection of iron-dextran (100 mg. of iron) administered on the day of birth, (2) approximately 2 lb. of fresh soil placed in the pen each day, (3) oral doses of an iron-copper paste (40 mg. of iron as ferrous sulfate and 2.5 mg. of copper as cupric sulfate) given on the day of birth and twice weekly thereafter and (4) a negative control (no supplemental iron). Thirty-six litters were randomly assigned to the three positive iron treatments, 12 litters each, from outcome groups of similar farrowing date and four additional litters were assigned to the negative control treatment. Individual pig weights were collected at birth, 1, 3 and 5 weeks of age and hemoglobin levels were obtained at birth, 3 and 5 weeks of age.

*Experiment III.* Because sow milk is very low in iron content (Venn *et al.*, 1947), the age at which pigs are weaned has an effect on the quantity of iron ingested from dietary sources. Therefore, a study was conducted to find the optimum allowances of iron as iron-dextran for pigs weaned at either 3 or 8 weeks of age. Forty Landrace baby pigs from seven litters were utilized in the experiment. The management of the sows and litters was similar to that in the previous experiments with the following exceptions: (1) the sows were hand-watered twice daily, (2) sows and litters were moved to concrete-floored pens when the litters were 5 days of age, and (3) the pigs were offered a creep ration containing approximately 90 p.p.m. of iron when they reached 2 weeks of age. Four levels of iron-dextran, furnishing 0, 50, 100 and 200 mg. of iron, were compared with pigs suckling until 8 weeks of age and with pigs weaned at 3 weeks of age. The pigs were injected intramuscularly with their allowance of iron-dextran on the day of birth, with the exception of pigs receiving 200 mg. of iron. Those animals were administered 100 mg. on the day of birth and an additional 100 mg. when 3 weeks of age.

A split-plot experimental design was used. At birth the baby pigs were

randomly assigned to the sub-plot iron treatments from outcome groups of similar birth weights within litter. When the pigs reached 3 weeks of age, the previously mentioned outcome groups were randomly assigned to the main-plot "on-sow" and "off-sow" treatments. Complete litter control was maintained across iron treatments; however, in respect to "on-sow" and "off-sow" treatments, litter control was possible in only three of the five replications.

## Results and Discussion

*Experiment I.* The data reported are a summary of the 132 pigs living at 5 weeks of age (table 1). The hemoglobin data revealed a decided advantage for the pigs which had received the iron-dextran. The single in-

TABLE 1. HEMOGLOBIN AND WEIGHT DATA FOR PIGS IN EXPERIMENT I

| | Hemoglobin (gm./100 ml. blood) | | Weights (lb.) | |
|---|---|---|---|---|
| Age in days | Iron-dextran | Fe-Cu paste | Iron-dextran | Fe-Cu paste |
| 0 | 8.28 | 8.52 | 2.92 | 2.98 |
| 7 | .... | .... | 5.77 | 5.86 |
| 14 | .... | .... | 9.06 | 9.03 |
| 18 | 10.22[a] | 7.58 | .... | .... |
| 21 | .... | .... | 13.10 | 12.49 |
| 28 | .... | .... | 16.40 | 15.28 |
| 35 | 8.73[b] | 7.70 | 19.61[c] | 18.38 |

[a] Eighteen-day hemoglobin levels differ significantly ($P<0.01$).
[b] Thirty-five-day hemoglobin levels differ significantly ($P<0.01$).
[c] Thirty-five-day body weights differ significantly ($P<0.01$).

jection of 100 mg. of iron as iron-dextran was adequate for at least the first 3 weeks postpartum (figure 1). The oral treatment did not prevent the development of an iron deficiency as evidenced by hemoglobin levels. Statistical analysis of the treatment effects at both 18 and 35 days proved these differences to be highly significant—99% confidence limits for the treatment differences=$2.64\pm0.63$ and $1.03\pm0.76$ gm. of hemoglobin per 100 ml. of blood, respectively. The growth curves (figure 2) revealed an interesting relationship between growth rate and hemoglobin level. During the 2- to 4-week period the iron-dextran group gained an average of 1.08 lb. more than the orally treated group. This period coincided with the time when the average difference in treatment hemoglobin levels was the greatest. Statistical analysis of 0- to 5-week gains revealed a highly significant difference between treatment means—99% confidence limits for the treatment difference=$1.23\pm1.09$ lb. The observed mortalities in treatment groups were essentially the same; 12% in the oral treatment group and 11% in the iron-dextran treatment group.

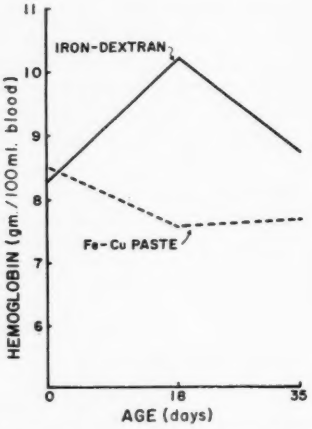


Figure 1. The effects of the iron treatments of Experiment I on hemoglobin levels.

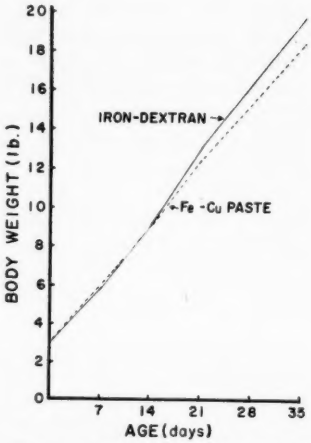


Figure 2. The effects of the iron treatments of Experiment I on growth rates.

*Experiment II.* A summarization of the data of the 329 pigs living at 5 weeks of age is presented in table 2. The hemoglobin data showed favorable positive responses from the three supplemental iron treatments (figure 3). At 5 weeks of age the average hemoglobin levels of the soil and paste treatment groups had slightly surpassed the iron-dextran group; 11.1, 10.6 and 10.4 gm. per 100 ml. of blood, respectively. The hemoglobin levels of the negative control group demonstrate the rapid development of an iron deficiency in unsupplemented suckling pigs. By 3 weeks of age the level had reached a low of 6.2 gm. per 100 ml. of blood. As in

TABLE 2. HEMOGLOBIN AND WEIGHT DATA OF PIGS IN EXPERIMENT II

| Iron treatment | No. of litters | Weeks of age | | | |
|---|---|---|---|---|---|
| | | 0 | 1 | 3 | 5 |
| | Hemoglobin (gm./100 ml. blood) | | | | |
| Control | 4 | 9.04 | 6.64 | 6.23 | 6.35 |
| Iron-dextran | 12 | 9.62 | .... | 10.36 | 10.40 |
| Soil | 12 | 8.83 | .... | 10.01 | 11.06 |
| Fe-Cu paste | 12 | 9.25 | .... | 10.19 | 10.64 |
| | Body weight (lb.) | | | | |
| Control | 4 | 2.77 | 5.26 | 10.76 | 15.42 |
| Iron-dextran | 12 | 2.98 | 5.55 | 12.38 | 19.30 |
| Soil | 12 | 2.78 | 5.20 | 11.73 | 18.71 |
| Fe-Cu paste | 12 | 2.77 | 5.07 | 11.56 | 18.07 |

Experiment I the iron-dextran injected pigs grew faster than either the soil or iron-copper paste treated pigs (figure 4). Body weight gains from 0 to 5 weeks of age averaged 16.3, 15.9 and 15.3 lb., respectively. Although the weight difference between the iron-dextran and the iron-copper paste treatments was of a similar magnitude to that in Experiment I, it did not prove to be statistically significant. This probably results from the fact that, because of the type of treatments, it was necessary to use an experimental design of lower precision. The iron deficiency of the negative control pigs was reflected by their poor growth rate.

*Experiment III.* The hemoglobin and weight data (table 3) again reveal

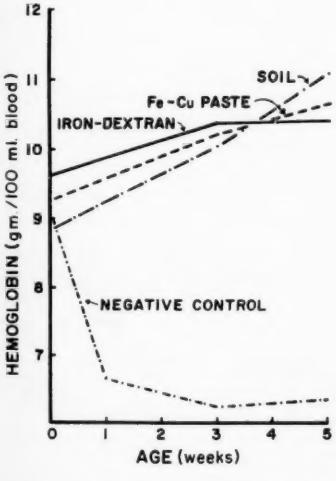


Figure 3. The effects of the iron treatments of Experiment II on hemoglobin levels.

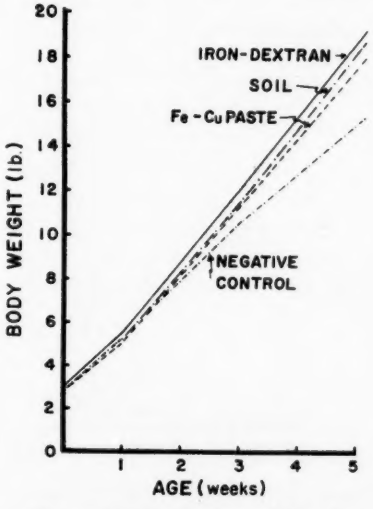


Figure 4. The effects of the iron treatments of Experiment II on growth rates.

the value of iron-dextran as a source of iron for the prevention of iron-deficiency anemia. At 3 weeks of age there was a statistically significant, linear increase in hemoglobin levels with increasing quantities of injected iron. Also, the weights of pigs which were injected with 50 or 100 mg. of iron averaged significantly greater ($P<0.01$) than those of animals which did not receive supplemental iron.

With the exception of the pigs receiving a second injection of 100 mg. of iron, hemoglobin levels of suckling pigs decreased between 3 and 6 weeks of age and then increased between 6 and 8 weeks of age. This positive hemoglobin response was related to the intake of a substantial quantity

of a starter ration containing approximately 90 p.p.m. of iron. Feed consumption records showed that until the suckling pigs were 6 weeks of age only small quantities of the creep ration were consumed. At 4, 6 and 8 weeks of age each increasing increment of supplemental iron produced a higher average hemoglobin level in the suckling pigs. The linear component of the effect of supplemental iron on hemoglobin levels was highly significant ($P<0.01$).

A rapid increase in hemoglobin levels was observed after pigs were weaned at 3 weeks of age. This increase can be attributed to the intake of

TABLE 3. HEMOGLOBIN AND WEIGHT DATA OF PIGS IN EXPERIMENT III

| Iron dextran (mg. Fe) | Weeks of age | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | | 4 | 6 | 8 |
| | Hemoglobin (gm./100 ml. blood) | | | | | | | |
| 0 | 10.90 | 7.40 | 6.50 | 5.61[a] | on sow | 5.18 | 4.60 | 6.60[c] |
| | | | | | off sow | 7.16 | 9.84 | 10.34 |
| 50 | 10.41 | 9.00 | 8.17 | 7.30[a] | on sow | 6.72 | 6.84 | 9.04[c] |
| | | | | | off sow | 8.40 | 9.90 | 10.68 |
| 100 | 9.35 | 8.90 | 9.81 | 8.80[a] | on sow | 7.48 | 7.36 | 9.50[c] |
| | | | | | off sow | 9.04 | 10.18 | 10.58 |
| 200 | 10.12 | 8.75 | 9.58 | 8.45[a] | on sow | 9.94 | 8.90 | 10.54[c] |
| | | | | | off sow | 10.68 | 10.86 | 10.48 |
| | Body weight (lb.) | | | | | | | |
| 0 | 3.41 | 6.51 | 10.29 | 12.84[a] | on sow | 13.62 | 18.40 | 28.90[d] |
| | | | | | off sow | 15.58 | 23.20 | 43.44 |
| 50 | 3.52 | 6.85 | 11.27 | 14.41 | on sow | 16.58 | 25.82 | 40.60[d] |
| | | | | | off sow | 17.18 | 25.82 | 44.94 |
| 100 | 3.37 | 6.81 | 10.35 | 13.91 | on sow | 15.86 | 24.98 | 41.30[d] |
| | | | | | off sow | 17.32 | 27.44 | 48.20 |
| 200[b] | 3.29 | 6.84 | 11.00 | 14.92 | on sow | 17.22 | 27.30 | 44.80[d] |
| | | | | | off sow | 17.80 | 26.48 | 47.52 |

[a] Linear regression of hemoglobin levels at 3 weeks of age on iron levels was significant ($P<0.01$).
[b] This weight is significantly less than others at 3 weeks of age ($P<0.01$).
[c] Linear regression of hemoglobin levels at 8 weeks of age on iron levels was significant ($P<0.01$).
[d] Linear regression of body weights at 3 weeks of age on iron levels was significant ($P<0.01$).

a substantial quantity of iron in the diet. A further hemoglobin response was noted in the animals which were injected with a second 100 mg. of iron at 3 weeks of age. These animals had almost reached their maximum hemoglobin level at 4 weeks of age. By 8 weeks of age the hemoglobin levels of all the early-weaned pigs were essentially equal.

The iron-deficiency anemia in the suckling pigs which did not receive supplemental iron prevented a normal rate of growth. A substantial growth stimulation was obtained with an injection of 50 mg. of iron as iron-dextran. Further, but less marked, increases were obtained with added increments (100 and 200 mg.) of iron. The linear component of the iron treatment effect on the 8-week weights of suckling pigs was highly significant ($P<0.01$). When pigs were weaned at 3 weeks of age, the iron-dextran had less effect on growth rates. Maximum growth was obtained with 100 mg. of iron.

## Summary

Two experiments were conducted to compare the effectiveness of injectable iron-dextran and various oral iron treatments in preventing iron-deficiency anemia of suckling baby pigs reared in confinement. A third experiment was designed to determine the level of iron as iron-dextran necessary for maximum growth rate, both for pigs weaned at 3 weeks of age and for pigs allowed to nurse to 8 weeks of age.

In Experiment I a single 2 ml. intramuscular injection of iron-dextran (100 mg. of elemental iron) administered on the second day of age was superior to weekly oral doses of an iron-copper paste (28 mg. of iron as ferrous sulfate and 2 mg. of copper as cupric sulfate) in preventing iron-deficiency anemia. In Experiment II, 2 ml. of iron-dextran (100 mg. of iron) injected on the day of birth, fresh soil provided daily or an iron-copper paste (40 mg. of iron as ferrous sulfate and 2.5 mg. of copper as cupric sulfate) administered twice weekly were effective in preventing anemia. Body weight gains from 0 to 5 weeks of age averaged 16.3, 15.9 and 15.3 lb., respectively. In Experiment III, 2 ml. of iron-dextran (100 mg. of iron) injected on the day of birth was required for maximum rate of growth when pigs were weaned at 3 weeks of age, whereas injections of 100 mg. of iron on the day of birth followed by 100 mg. on the 21st day of age were required for maximum growth by pigs nursing until 8 weeks of age.

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# EFFECT OF NUTRITION ON THE PRODUCTIVITY OF RANGE SHEEP [1]

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APPROXIMATELY 100,000 head of sheep graze the federally controlled lands of southeastern Nevada and southwestern Utah during the winter and graze privately owned land near the Dixie National Forest in southwestern Utah during the summer. Lowered production and large death losses in the early 1950's indicated a need for winter range nutrition studies in the area.

Harris *et al.* (1952) outlined four phases of range nutrition research which are necessary before recommendations can be made to stockmen on feeding supplements and management practices. These phases include (1) factors that affect the chemical composition of a given range species, (2) the botanical and nutritive composition of the sheep's diet, (3) supplementary feeding trials on a detailed experimental basis, and (4) supplementary feeding trials on a practical basis using some of the most valuable supplements in various combinations, amounts, and seasons. The first, second, and third phases of such a study have been conducted by Utah research workers. These studies have shown that (1) sheep are very selective in choosing their diet, (2) vegetative type, stage of growth, and site affect the nutritive content of the range forage, (3) most of the desert-type winter ranges provide inadequate amounts of phosphorus, protein and energy for optimum production in range ewes. Requirements for economic production have been suggested by Cook and Harris (1950a, b), Cook *et al.*, (1948, 1954) and Harris *et al.*, (1952, 1956). Essentially no work has been done using sheep from different sources to study differences due to a carry-over effect from previous management.

The purpose of the experiment was to determine if supplements were required on the winter ranges of southwestern Utah and southeastern Nevada and the effects of body condition, different ownership and age on the needs for supplements.

## Experimental Procedure

Four-hundred fifty range ewes were borrowed from each of two sheep owners in the area. They consisted of equal numbers of six age groups:

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lambs, 1, 2, 3, 4 and over 4 years. Throughout the winter the sheep were handled as the majority of the sheepmen in the area handled their bands. The exception to this was the feeding method and the supplements fed. Following initial weighing and ear tagging, the ewes were stratified by

TABLE 1. EXPERIMENTAL DESIGN FOR FEEDING THREE SUPPLEMENTS DURING THREE SEASONS WHILE THE EWES WERE ON THE WINTER RANGE

| Supplement | Age of ewes | Season[a] | | | Total | Control ewes[b] | Replacements |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | | | |
| | | Number of ewes | | | | | |
| Corn | Lambs | 14 | 14 | 14 | 42 | 14 | 10 |
| | 1 | 14 | 14 | 14 | 42 | 14 | 10 |
| | 2 | 14 | 14 | 14 | 42 | 14 | 10 |
| | 3 | 14 | 14 | 14 | 42 | 14 | 10 |
| | 4 | 14 | 14 | 14 | 42 | 14 | 10 |
| | 5 and over | 14 | 14 | 14 | 42 | 14 | 10 |
| Phosphorus pellet[c] | Lambs | 14 | 14 | 14 | 42 | | |
| | 1 | 14 | 14 | 14 | 42 | | |
| | 2 | 14 | 14 | 14 | 42 | | |
| | 3 | 14 | 14 | 14 | 42 | | |
| | 4 | 14 | 14 | 14 | 42 | | |
| | 5 and over | 14 | 14 | 14 | 42 | | |
| Protein pellet[d] | Lambs | 14 | 14 | 14 | 42 | | |
| | 1 | 14 | 14 | 14 | 42 | | |
| | 2 | 14 | 14 | 14 | 42 | | |
| | 3 | 14 | 14 | 14 | 42 | | |
| | 4 | 14 | 14 | 14 | 42 | | |
| | 5 and over | 14 | 14 | 14 | 42 | | |
| Total | | 252 | 252 | 252 | 756 | 84 | 60 |

[a] The ewes in season 1 were fed from November 9, 1954 to April 15, 1955; the ewes in season 2 from January 18, 1955 to April 15, 1955; and those in season 3 from December 28, 1954 to March 8, 1955.

[b] These ewes received range forage only.

[c] The phosphorus pellet contained in %: oat straw, 88.68; dried cane molasses (Omalass) 2.5; distillers dried solubles (Vacatone), 2.5; iodized salt, 1.0; dicalcium phosphate, 5.32. This pellet contained 94.25% dry matter, 4.22% protein, 1.23% phosphorus and 3.55 kcal./gm.

[d] The protein pellet contained in %: alfalfa hay, 10.0; cottonseed oil meal, 13.65; barley, 72.43; dried cane molasses (Omalass), 2.5; iodized salt, 1.0; dicalcium phosphate, 0.42. This pellet contain 90.0% dry matter, 22.1% protein, 0.6% phosphorus and 3.95 kcal./gm.

owner, age, condition and weight classes and allotted at random to the treatments as outlined in table 1.

A modified factorial design was used to observe the effects of three supplements fed at three different seasons (table 1). The tenth group of ewes acted as the control or base group and received no supplement. The ewes were identified with paint number brands on the back and by this identification they were separated every other day through a four-way reversible cutting chute for group feeding.

A preliminary range survey was made before the feeding trial began to obtain an estimate of deficient nutrients which would probably occur in the sheep's diet (table 2). This survey was based on vegetative composition and preferred indexes as outlined by Cook *et al.* (1954). On the basis of this survey three supplements were selected, a pellet designed to meet the protein and phosphorus deficiencies, whole corn, and phosphorus in a straw base pellet. The first two were fed at the rate of 0.25 lb. (air dry) per day and the latter at 0.125 lb. per day (actual feeding was twice these amounts every second day).

Composition of the actual diet was estimated by close observation of

TABLE 2. ESTIMATED NUTRIENT CONTENT OF THE SHEEP'S DIET BASED ON A PRELIMINARY SURVEY AND ACTUAL DIET AFTER OBSERVING SHEEP GRAZE, REQUIREMENTS AND SUPPLEMENTS TO CORRECT DEFICIENCIES

| | Forage consumed (dry basis) | Dig. protein | | Met. energy | | Phosphorus | |
|---|---|---|---|---|---|---|---|
| | lb. | % | lb. | Kcal./lb. | Kcal. | % | oz. |
| Preliminary survey range forage | 3.300[a] | 4.3 | 0.14 | 556 | 1834 | 0.14 | 0.07 |
| Requirements[a] | 3.590 | 4.4 | 0.16 | 663 | 2379 | 0.17 | 0.10 |
| Actual diet range forage[b] | 3.300[a] | 4.8 | 0.16 | 555 | 1832 | 0.12 | 0.06 |
| Supplements[c] | | | | | | | |
| Protein pellet | .225 | 20.8 | 0.05 | 1614 | 363 | 0.70 | 0.03 |
| Corn | .225 | 7.6 | 0.02 | 1581 | 356 | 0.31 | 0.01 |
| Phosphorus pellet | .112 | 0.7 | .... | 702 | 79 | 1.31 | 0.03 |

[a] Figures based on experimental data by Cook *et al.* (1954).
[b] Figures taken from table 3.
[c] Figures based on actual chemical analyses and estimates of digestibility and metabolizable energy as taken from Cook *et al.* (1954).

the grazing sheep for specific intervals at different times during the winter. Forage samples representing the sheep's diet were collected for chemical analyses. From the composition, chemical analyses and digestion coefficients reported by Cook *et al.* (1954), the estimated nutrient intake from the native forage was calculated (table 3). The estimated nutrient intake from the forage did not meet the requirements for energy and phosphorus (table 2); however, the supplements used corrected these deficiencies.

The snow was unusually deep during the winter accompanied by low temperatures. The spring was dry and windy. The weather and range conditions combined with a problem of adapting a band of sheep to a range other than the one they were accustomed to, influenced grazing habits.

The measures used to determine treatment, age and owner differences during this experimental period were (1) ewe weights, (2) ewe condition,

(3) plasma inorganic phosphorus and vitamin A, (4) wool weights, shrinkage and staple length, (5) ewe mothering and milking performance at lambing time, and (6) lamb birth weights, vigor and weaning weights. All ewe weights and lamb weaning weights were taken after an overnight shrink. The condition scores of the ewes were an estimate of the flesh covering over the back and ribs. These scores ranged from one (very fat) to five (very thin). Samples of wool were taken from the side of each

TABLE 3. AVERAGE COMPOSITION AND NUTRIENT CONTENT OF THE DIET THROUGHOUT THE WINTER GRAZING SEASON, BASED ON ESTIMATED DIETARY INTAKES AND ACTUAL CHEMICAL ANALYSES OF LIKE FORAGE

| Species of plants | Vegetative composition of diet | Dig. protein[a] | Phosphorus | Metabolizable energy[a] |
|---|---|---|---|---|
| | % | % | % | Kcal./lb. |
| Artemisia arbuscula | 7 | 5.2 | 0.15 | 575[b] |
| Artemisia nova | 29 | 4.7 | 0.13 | 500 |
| Artemisia spinescens | T | ... | .... | ... |
| Artemisia tridentata | 20 | 5.3 | 0.15 | 559 |
| Atriplex canescens | 2 | 5.5 | 0.13 | 458[b] |
| Atriplex confertifolia | 1 | 4.3 | 0.08 | 399 |
| Chrysothamnus stenophyllus | 3 | 3.4 | 0.10 | 773 |
| Cowania stansburiana | 1 | 4.3 | 0.12 | 650[b] |
| Ephedra nevadensis | 6 | 5.0 | 0.10 | 520[b] |
| Eurotia lamata | 16 | 6.2 | 0.10 | 594 |
| Grayia spinosa | 6 | 4.3 | 0.08 | 520[b] |
| Hilaria jamesii | 6 | 1.5 | 0.06 | 591 |
| Oryzopsis hymenoides | 2 | 1.5 | 0.07 | 721 |
| Sitanion hystrix | 1 | 3.5 | 0.09 | 782 |
| Tetradymia spp. | T | ... | .... | ... |
| Content in diet | 100 | 4.8 | 0.12 | 555 |

[a] Digestion and metabolism coefficients taken from data by Cook *et al.* (1954).
[b] Estimated values of plants similar to these.

sheep at shearing and were washed and air dried to estimate wool shrinkage. All differences discussed are statistically significant unless otherwise stated. A multiple range test was used to separate the means of measures containing significant differences. Milking ability was scored sufficient or non-sufficient depending upon the lambs satisfaction and response the first four or five days. All ewes and lambs that died were autopsied to determine the cause of death.

## Results and Discussion

All of the ewes lost weight the forepart of the winter and gained weight the latter part of the winter (figure 1). The protein supplement was most

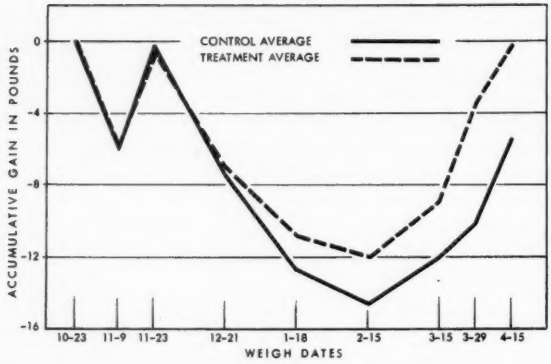


**Figure 1. Treatment effect on average weight changes of the ewes, by weigh dates.**

favorable in maintaining body weight, followed by corn, phosphorus and range forage only (table 4). Those fed fall, winter, and spring maintained body weight better than those fed in late winter and spring or midwinter (tables 4 and 5 and figure 2). The old ewes and lambs did not maintain their weight as well as the middle-aged and young ewes (tables 4 and 5 and figure 3). Owner 1's sheep lost about 4 lb. average from October until April while Owner 2's gained 0.7 lb. average (table 4 and figure 3). There

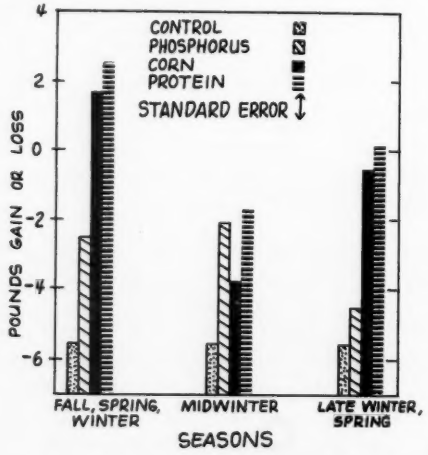


**Figure 2. The effect of season and kind of supplement fed on the gain in body weight from October 23, 1954 to April 15, 1955.**

was an interaction of owner and kind of supplement fed. Owner 1's ewes maintained weight better on the protein feed than did Owner 2's ewes (table 5 and figure 4).

The body condition scores were closely related to the weight changes until the month before lambing. Then the condition continued to decline

TABLE 4. TREATMENT, AGE, AND OWNER EFFECT ON MEASURES OF PRODUCTION AND BODY CHANGES OF THE EWES, OCTOBER 23 TO APRIL 15

| Treatment | October weight | Change in weight | October condition | Change in condition | Lamb weaned per ewe bred | Clean wool |
|---|---|---|---|---|---|---|
| | lb. | lb. | score | | lb. | lb. |
| Kind of supplement | | | | | | |
| Phosphorus | 107 | −3.1 | 2.83 | −0.98 | 46.3 | 2.85 |
| Corn | 107 | −0.7 | 2.82 | −0.76 | 48.6 | 2.84 |
| Protein | 107 | 0.3 | 2.79 | 0.73 | 54.7 | 2.84 |
| Season | | | | | | |
| 1. Fall, winter, and spring (November 9–April 15) | 107 | 0.6 | 2.85 | −0.64 | 50.6 | 2.81 |
| 2. Late winter and spring (January 18–April 15) | 107 | −1.6 | 2.82 | −0.87 | 48.9 | 2.80 |
| 3. Midwinter (December 28–March 8) | 107 | −2.4 | 2.77 | −0.95 | 50.2 | 2.92 |
| Kind of supplement and season | | | | | | |
| 1. Phosphorus in season 1 | 107 | −2.7 | 2.89 | −0.86 | 48.7 | 2.80 |
| 2. Corn in season 1 | 108 | 1.8 | 2.89 | −0.54 | 51.0 | 2.77 |
| 3. Protein in season 1 | 106 | 2.6 | 2.78 | −0.53 | 52.0 | 2.86 |
| 4. Phosphorus in season 2 | 107 | −4.6 | 2.83 | −1.10 | 41.8 | 2.71 |
| 5. Corn in season 2 | 106 | −0.3 | 2.80 | −0.84 | 49.5 | 2.89 |
| 6. Protein in season 2 | 107 | 0.1 | 2.83 | −0.68 | 55.4 | 2.80 |
| 7. Phosphorus in season 3 | 107 | −2.0 | 2.78 | −0.97 | 48.4 | 3.04 |
| 8. Corn in season 3 | 108 | −3.7 | 2.77 | −0.91 | 45.3 | 2.86 |
| 9. Protein in season 3 | 107 | −1.6 | 2.77 | −0.91 | 56.8 | 2.87 |
| Average of treated | 107 | −1.2 | 2.82 | −0.82 | 49.9 | 2.84 |
| Control | 107 | −5.6 | 2.86 | −1.23 | 42.2 | 2.65 |
| Age | | | | | | |
| Lambs | 73 | −2.3 | 2.80 | −0.81 | .... | 2.40 |
| Yearlings | 97 | 2.9 | 2.90 | −0.44 | 31.0 | 3.00 |
| 2-year-olds | 108 | −1.1 | 2.66 | −0.89 | 50.1 | 3.02 |
| 3-year-olds | 120 | −1.6 | 2.68 | −1.02 | 58.3 | 2.95 |
| 4-year-olds | 121 | −3.2 | 2.84 | −1.04 | 56.2 | 2.90 |
| 5-year-olds or older | 125 | −4.2 | 3.06 | −1.24 | 50.0 | 2.68 |
| Owner | | | | | | |
| 1 | 110 | −3.9 | 2.73 | −1.13 | 52.3 | 2.77 |
| 2 | 104 | 0.7 | 2.92 | −0.68 | 45.9 | 2.88 |

although the ewes were gaining weight. A comparison of figures 1 and 5 show the weight and condition relationship.

The condition of the sheep was associated with the type and season of supplementation. The control group lost the most condition followed by the groups supplemented in midwinter (tables 4 and 5 and figure 6). The sheep receiving phosphorus did not maintain condition as well as those receiving corn or protein. Protein and corn supplements were about equal during fall, winter and spring; and late winter and spring; however, in mid-winter the protein supplement exceeded the corn.

TABLE 5. ANALYSIS OF VARIANCE OF WEIGHT CHANGES, BODY CONDITION CHANGES, CLEAN WOOL WEIGHTS, AND LAMB BIRTH AND WEANING WEIGHTS

| | | Mean squares | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Weight changes | | Condition changes | | | | Mean squares | |
| Source of variation | Degrees of freedom | Oct. 23 to Feb. 15 | Oct. 23 to Apr. 15 | Oct. 23 to Jan. 18 | Oct. 23 to Apr. 15[a] | Clean wool weight | Degrees of freedom | Birth weights | Weaning weights |
| Total | 839 | | | | | | 699 | | |
| Age | 5 | 649.9** | 858.3** | 6.79** | 15.20** | 8.17** | 4 | 281.87** | 16285.81** |
| Owner | 1 | 2750.5** | 4338.4** | 16.02** | 33.68** | 2.19* | 1 | 116.28* | 7238.57* |
| Treatment | 9 | 277.1** | 604.1** | 3.34** | 4.50** | 0.94** | 9 | 36.54 | 1747.44 |
| Kind of supplement (A) | 2 | 504.3** | 795.0** | 1.97 | 5.42** | 0.01 | 2 | 29.06 | 3929.66 |
| Season (B) | 2 | 26.7 | 609.9** | 9.75** | 4.54** | 1.19* | 2 | 47.22 | 152.84 |
| A×B | 4 | 69.0 | 284.6** | 1.38 | 1.17** | 0.84 | 4 | 15.30 | 9065.88 |
| Control versus treated | 1 | 602.4** | 1488.9** | 1.12 | 15.84** | 2.72** | 1 | 115.15* | 3698.40 |
| Age×owner | 5 | 139.8** | 251.7** | 0.88 | 0.50 | 0.73 | 4 | 28.14 | 1312.23 |
| Age×treatment | 45 | 24.8 | 76.2 | 0.97 | 0.40 | 0.54* | 36 | 15.57 | 965.85 |
| Age×A | 10 | 23.2 | 58.0 | 0.86 | 0.22 | 0.70* | 8 | 18.21 | 613.69 |
| Age×B | 10 | 28.4 | 88.7 | 1.57* | 0.49 | 0.86** | 8 | * 25.69 | 1725.50 |
| Owner×treatment | 9 | 15.6 | 105.4 | 0.40 | 0.21 | 0.27 | 9 | 12.06 | 2022.60 |
| Owner×A | 2 | 29.0 | 228.2* | 0.88 | 0.88 | 0.14 | 2 | 30.28 | 6258.58* |
| Owner×B | 2 | 9.1 | 76.1 | 0.69 | 0.02 | 0.22 | 2 | 0.38 | 26.14 |
| Error[b] | 765 | 29.1 | 67.8 | 0.69 | 0.32 | 0.36 | 637 | 21.90 | 1547.75 |

[a] Analyses of covariance were used to adjust for the difference in initial condition.

[b] If degrees of freedom are subtracted for the estimation of missing values, the age × A effect on clean wool lost significance and the age × B effect on clean wool was reduced to significance at the 0.05 level.

* Significant at 5% level.

** Significant at 1% level.

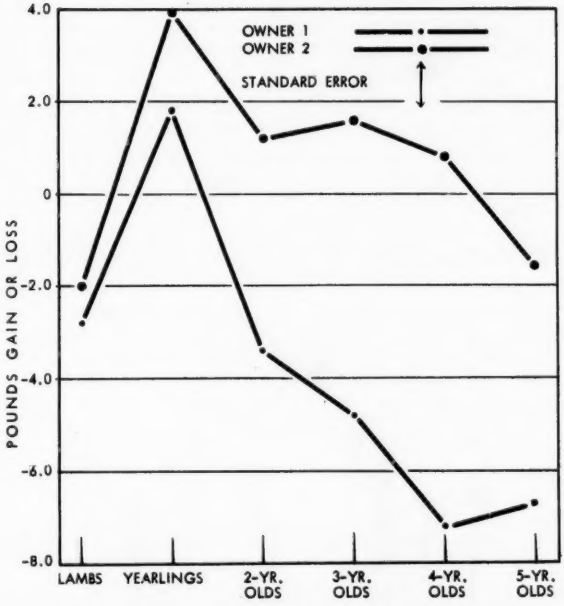


Figure 3. The effect of age and owner on the gain in the body weight from October 23, 1954 to April 15, 1955.

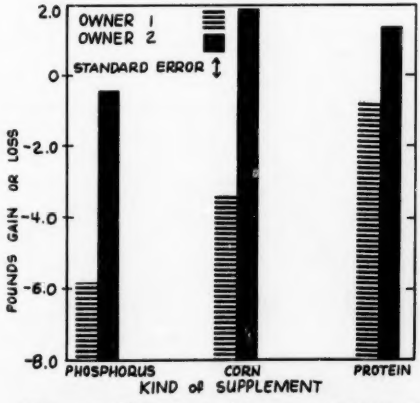


Figure 4. The effect of owner and kind of supplement fed on the gain in body weight from October 23, 1954 to April 15, 1955.

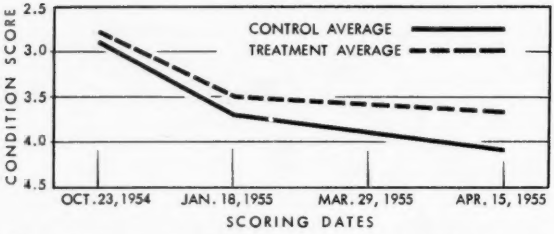


**Figure 5. Treatment effect on the average condition change of the ewes during the winter 1954–55.**

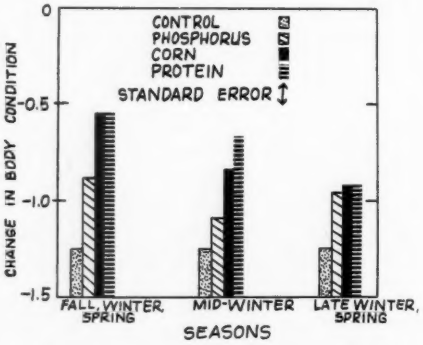


**Figure 6. The effect of season and kind of supplement fed on the changes in body conditions from October 23, 1954 to April 15, 1955.**

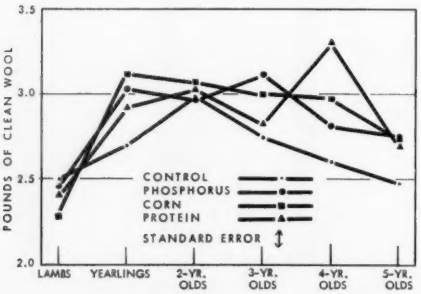


**Figure 7. The effect of age and kind of supplement on the pounds of clean wool produced.**

The lambs and old ewes lost most heavily in condition. Owner 1's sheep lost more condition than Owner 2's; however, Owner 1's sheep were in slightly better condition at the beginning of the experiment. The effect of the small initial difference in condition between owners was adjusted in the analysis by the use of covariance. The differences in condition changes due to age and ownership are shown in tables 4 and 5.

Very small differences in wool production were observed among the treatments. A significant difference was shown between the control ewes and the treated ewes (tables 4 and 5). Any method of supplementation produced beneficial effects. Slen and Whiting (1952a), using controlled individual feeding, showed that raising a diet from 3.3% to 6.3% digestible protein increased clean wool production.

In this experiment middle-aged ewes produced the most wool and the

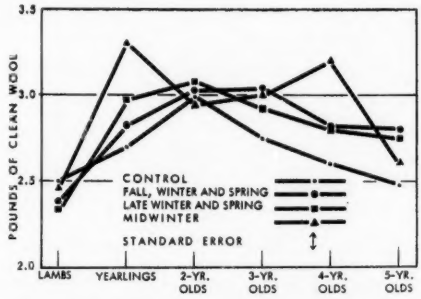


**Figure 8. The effect of age and season on the pounds of clean wool produced.**

lambs produced the least (table 4 and 5). Owner 1's ewes had a longer staple but yielded less clean wool than Owner 2's (tables 4 and 5). Interactions between age and kind of supplement fed, and age and season are shown in table 5 and figures 7 and 8.

The supplemented groups gave birth to heavier lambs than those not supplemented; however, this did not carry through for weaning weights (table 5). Slen and Whiting (1952b) found that increasing the digestible protein content of a diet from 3.3% to 6.3% increased the birth weight of lambs and the gains of the lambs the first six weeks after birth; however, these ewes were maintained on the same diet during lactation. Klosterman *et al.* (1953) found that it was difficult to influence lamb production by the amount of protein fed to pregnant ewes as long as the energy intake remained relatively constant.

Most lambs were strong at birth, however, the weakest ones were born to the control ewes. The mothering and the milking ability of the ewes was not affected greatly by the treatments. The old ewes produced the most lambs but did not wean as many pounds of lamb as the middle aged ewes.

Two-year-old ewes were the lowest producers (tables 4 and 5). The older ewes were the best mothers and the two-year olds were the poorest. There was a great difference in lamb production due to owners (tables 4 and 5). More of Owner 1's ewes lambed, and had more twins. Because of this the lambs were not as heavy or as strong as Owner 2's. Owner 1's ewes weaned more pounds of lamb than Owner 2's. Owner 1's ewes that had been fed protein produced significantly more pounds of lamb than the ewes receiving the other supplements (table 5 and figure 9).

A total production estimate was derived by assigning values to the wool and lamb produced by each ewe. There was no difference in the returns per ewe bred due to the treatments used. The age of ewe had a large effect on returns with young ewes returning the least. Owner 1's ewes yielded the largest returns; however, when the small difference in initial condition

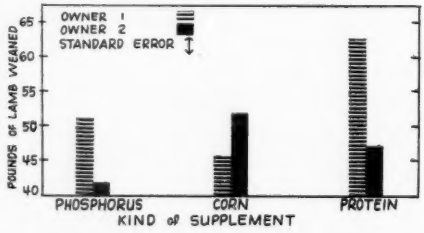


**Figure 9. The effect of owner and kind of supplement on the pounds of lamb weaned per ewe bred.**

was adjusted by the use of covariance, there was no difference in returns. There was an ownership and kind of supplement fed interaction on returns due to Owner 1's protein fed ewes producing more pounds of lamb. The changing values of feed, wool and lambs must be taken into account in economic interpretation or application.

Plasma inorganic phosphorus and vitamin A were determined on some ewes in midwinter. Phosphorus levels were normal and vitamin A was low, but no deficiency symptoms were observed. No difference in plasma inorganic phosphorus was due to differences in phosphorus supplementations.

Post-mortems were made on ewes and lambs that died. No one disease caused large losses. Pneumonia was the chief killer in the ewes. Starvation shortly after birth killed the most lambs. Differences in death loss among treatments were not significant although the control group had the largest loss. A larger loss occurred in the older ewes and the two-year old ewes lost the most lambs. Regardless of the cause of death, more of Owner 1's ewes died than Owner 2's. There was a larger lamb loss in Owner 1's sheep.

The differences in results due to the treatments used occurred in a definite pattern. Most of the measures used in the experiment showed that any of the treatments used gave improved performance over the control

group (tables 4 and 5). Many of these differences were significant. In order to have obtained larger differences among the treatments, it is felt that a larger quantity of the supplements should have been fed with an alteration in the seasons.

In general phosphorus supplementation produced a smaller response than the other supplements. Possibly the need for phosphorus supplementation was not as critical as that for energy and protein. Assuming a 3.3 lb. daily intake of forage, based on data by Cook et al. (1954), plus the phosphorus supplement, the ewes received 0.09 oz. (2.6 gm.) of phosphorus daily. The ewes receiving only forage had a daily intake of 0.06 oz. (1.7 gm.) The National Research Council (1949) recommends 2.6 gm. per day in early gestation and 3.2 gm. per day in late gestation for a 110-pound ewe. Beeson *et al.* (1945) reported that a daily intake of 2.47 to 2.43 gm. per 100 lb. of liveweight was adequate and that 2.11 gm. per 100 lb. of live weight was not adequate during gestation.

Although differences in weight and condition changes were marked in several treatment comparisons, small differences in lamb and wool production were observed. These weight differences accompanied by little or no difference in production are in agreement with work reported by Jordan (1950), Chittenden *et al.* (1935), and Van Horn *et al.* (1952). However, no mention was made by the above workers of the body condition of the ewes when going on the experiments. It is possible that ewes in high condition can lose weight and produce adequately whereas thinner ewes must gain weight. Slen and Whiting (1952a, b) used ewes in what they termed satisfactory condition and found that increasing the digestible protein content of the diet from 3.3% to 6.3% increased the gains only during the latter part of gestation. This increase in weight gain was followed by heavier lambs at birth which gained more rapidly the first six weeks and the ewes produced more clean wool. These ewes were held on the same diets during lactation which is not directly comparable to the work presented in this report and the work of Jordan (1950), Chittenden *et al.* (1935), Van Horn *et al.* (1952), and Klosterman *et al.* (1953).

The differential response between sheep from different owners has particular significance. All sheep were of similar appearance, white face and fine wool, however, there was a small difference in initial condition (table 4). These differences in production, apparently due to previous genetic and environmental influences, further complicate the interpretation and application of sheep nutrition research. Differences in production due to age of sheep and year of experiment has been shown previously by Harris *et al.* (1956).

It is therefore difficult to make specific practical recommendations. The individual operator must exercise a great deal of judgment in feeding his sheep. The kind and rate of supplement to be fed is influenced by the kind and quality of range forage; the condition, genetic make-up, and previous

management of the ewes; climatic conditions; and cost of supplement as related to returns of wool and lambs.

## Summary

Four hundred and fifty range ewes from each of two owners consisting of six age groups were maintained on desert-type winter range during the winter of 1954–55. Ten treatments including range forage only, and supplemental feeds of energy, protein and phosphorus during three seasons, November to April, January to April, and January to March were used.

Body condition changes are introduced as a measure of response. They help define body weight and they show that ewe gains in the spring are not necessarily due to increased flesh on the ewe.

Comparison of treated animals to nontreated animals did indicate definite improvement in maintenance of body weight and condition during the winter, in wool production and in lamb birth weights but not weaning weights. Differential feed treatments indicated no difference in lamb production among kinds of supplement and season. The midwinter fed groups produced more wool than those fed during other seasons. Kind of supplement had no effect on wool production. Protein feed and all-winter feeding maintained body weight and condition better than other combinations of feeding. Three-year-old ewes followed by 4-year-olds produced the most pounds of lamb. Yearlings, 2-year olds and 3-year-olds had nearly the same wool production. When combining lamb and wool production the 3- and 4-year-olds were the best producers. The yearling ewes maintained weight and condition better than the other age groups. Large ownership differences were observed. Owner 1's ewes lost more body weight and condition, produced more pounds of lamb and less wool than the ewes from Owner 2. These ownership differences, apparently due to previous genetic and environmental influences, emphasize another problem in the interpretation of nutrition experiments.

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# GESTATION LENGTH, BIRTH WEIGHT AND AGE AT FIRST CALVING OF CROSSBRED CATTLE WITH VARYING AMOUNTS OF RED SINDHI AND JERSEY BREEDING [1]

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SEVERAL reports (Dave, 1950; Lazarus and Anantakrirhnan, 1952; Littlewood, 1937) have shown that the average gestation length of Red Sindhi cattle is approximately 4–7 days longer than that generally given for Jerseys. Also, purebred Red Sindhis are smaller than Jerseys at birth (Dave, 1950; Lazarus and Rangaswamy, 1950; Joshi and Phillips, 1953; Rajagopolan, 1952; Rathore, 1949; Saxena, 1950). Further, there is some evidence from reports on age at first calving (Maule, 1953; Saxena, 1950; Stonaker *et al.*, 1953; Sundarsen *et al.*, 1954; Tandon, 1951) that purebred Red Sindhi cattle reach sexual maturity 6 to 12 months later than the normal age of most European breeds.

In order to determine the possible effects of varying degrees of Red Sindhi inheritance on gestation length, birth weight and age at first calving, data from the Red Sindhi-Jersey crossbreeding investigations conducted at three stations have been studied.

## Materials and Methods

Data used in this study were from the projects at the Agricultural Research Center, Beltsville, Maryland; the Iberia Livestock Experiment Station, Jeanerette, Louisiana; and the Georgia Coastal Plain Experiment Station, Tifton, Georgia. The breed groups consisted of purebred Jerseys and groups of ¾ Jersey-¼ Red Sindhi, ½Jersey-½ Red Sindhi (first generation) and ¼ Jersey-¾ Red Sindhi crosses. For brevity, the stations will be referred to as Beltsville, Jeanerette, and Tifton; the breed groups Jersey, ¾ J, $F_1$, ¼ J and Sindhi will be used throughout the remainder of the paper.

The $F_1$ crosses were produced by mating Sindhi bulls to Jersey cows; the ¾ J at Tifton were from mating $F_1$ crossbred males to Jersey females but at Beltsville and Jeanerette, the ¾ J groups also included reciprocals;

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the ¼ J were produced by backcrossing $F_1$ females to purebred Sindhi bulls.

In the study of gestation length only those of purebred Jerseys and $F_1$ Sindhi-Jersey cows were used. The Jerseys were those which produced purebred and one or more crossbred calves. The $F_1$ females were those which produced calves from matings to purebred Sindhi and/or Jersey bulls. The gestation period was taken as the number of days from date of breeding through date of calving. Only those gestations which terminated with the birth of a single, living calf were considered.

The birth weights of the calves were taken within 12 hours after parturition. The purebred Jersey calves were maternal half-sibs to the crossbreds. The ¾ J calves at Tifton were by $F_1$ crossbred bulls and out of Jersey cows only. Those at Beltsville and Jeanerette were by Jersey bulls and out of F/ crossbred cows as well as by crossbred bulls and out of Jersey cows. The halfbreds were from matings of Sindhi to Jersey cows. The ¼ J calves were the result of backcrosses to the $F_1$ females.

The intended age of first calving was two years of age at Beltsville and Tifton and 2 years and 3 months in the Jeanerette herd. Therefore, age of first breeding was the first estrus following 15 months of age in Beltsville and Tifton herds and 18 months at Jeanerette. Estrus was established from observations by experienced personnel two or more times daily commencing at 12 months in the Beltsville and Tifton herds and 15 months of age in the Jeanerette herd. The age of first estrus was calculated as the number of days from birth to the first recorded behavioral estrus. Breedings for second gestation commenced 60, 70 and 85 days following parturition at Tifton, Jeanerette and Beltsville, respectively.

The calvings at all stations were rather evenly distributed throughout the year.

## Results and Discussion

*Gestation Length.* Reports have indicated that age of dam, sex, sire and interaction of these variables can affect gestation length in cattle (Buch *et al.*, 1959; Jafar *et al.*, 1950; Tandon, 1951). As these factors did not have the same effect on all breed groups in this study, the effects of each were determined and adjustments made before breed group differences were studied.

Age of dam was associated with sex, sire and station as well as weight differences, thus its effect was determined independently of these factors. Using an anlysis of variance for disproportionate sub-class numbers with an R x 2 table (Snedecor, 1956), it was found that the gestation periods of both male and female calves resulting from the first calving were significantly less than those from later calvings at Beltsville and Tifton; however, the differences were not significant at Jeanerette. The effect of age of dam on later gestations was not significant at any station. The

gestation lengths for first parturition at Beltsville and Tifton were adjusted to a mature basis within sex.

Sex differences were not significant. Sires within breeds and interaction of sire and sex were significant. The interaction of sex and breed was significant at Jeanerette, but it was not in the Beltsville and Tifton groups.

After adjustments were made for age of dam and sire effects, the breeding group differences were found to be significant ($P<.01$). The group means are shown in table 1. All Jerseys carrying Jersey offspring had gestation lengths generally attributed as characteristic of the breed, but when these same cows were mated to $F_1$ crossbred and purebred Sindhi bulls, the calves were carried 2 to 4 and 5 to 8 days longer, respectively. The $F_1$ crossbred cows mated to Sindhi bulls carried their calves about 5 days longer than when these same cows were mated to Jersey bulls.

The gestation periods of the Jersey, ¾ J and $F_1$ groups were significantly longer at Beltsville than at the other stations although the relationships

TABLE 1. MEAN GESTATION LENGTH OF JERSEY AND $F_1$ COWS WHEN CARRYING VARIOUS TYPES OF FETUSES ADJUSTED FOR AGE OF DAM

| | Jersey | | ¾ J | | $F_1$ | | ¼ J | |
|---|---|---|---|---|---|---|---|---|
| Herd | No. | Mean | No. | Mean | No. | Mean | No. | Mean |
| | | days | | days | | days | | days |
| Beltsville | 183 | 281.0±.27 | 49 | 284.6±1.11 | 92 | 288.6±.68 | 58 | 289.3±.44 |
| Jeanerette | 159 | 279.3±.25 | 85 | 282.2± .81 | 119 | 284.9±.58 | 38 | 288.3±.70 |
| Tifton | 100 | 279.5±.46 | 45 | 282.1± .71 | ... | ..... ... | .. | ..... ... |

among breed groups were similar. Seasonal effects on length of gestation were small but those pregnancies terminating from April through September at Jeanerette and Tifton tended to be slightly shorter which may account, in part, for some of the differences between stations.

From these data it is apparent that gestation length tended to vary directly with the degree of Sindhi inheritance carried by the fetus.

There were five purebred Sindhi cows at Jeanerette that terminated 18 pregnancies to Sindhi bulls. The average gestation length was 291 days for all calves of both sexes. This is about three days longer than the average given in reports by Littlewood (1937) and Tandon (1949). If, however, it is assumed that 291 days is characteristic for the Sindhis used in these studies, then an additive genetic effect for gestation length is suggested. The lengthening of the gestation period with the increasing amount of Zebu inheritance follows the trend reported by Howe (1949) but is more pronounced. The additive effect conclusion is contrary to that reported by Tandon (1949) in crosses of Sindhis with Jerseys. Tandon concluded that the factors determining short gestation are present in the Jersey breed and seem to be more potent than the factors determining the longer gestation of the Sindhi breed. It is possible that his results may

TABLE 2. MEAN BIRTH WEIGHTS OF OFFSPRING FROM JERSEY AND $F_1$ COWS ADJUSTED FOR AGE OF DAM

| Herd | Jersey | | ¾ J | | $F_1$ | | ¼ J | |
|---|---|---|---|---|---|---|---|---|
| | No. | Mean | No. | Mean | No. | Mean | No. | Mean |
| | | lb. | | lb. | | lb. | | lb. |
| Beltsville | 183 | 59.6±.77 | 49 | 61.1±2.19 | 92 | 71.6±1.30 | 58 | 58.5±1.04 |
| Jeanerette | 159 | 58.5±.56 | 85 | 60.5± .91 | 119 | 65.1± .69 | 38 | 58.4± .97 |
| Tifton | 100 | 56.7±.91 | 45 | 66.2±1.67 | ... | .... .... | .. | .... .... |

have agreed more closely with present study if he had maintained contemporary Jerseys.

*Birth Weight.* It has been shown that the factors effecting gestation length usually influence birth weight in cattle of all types (Tandon, 1951; Tyler *et al.*, 1947). Procedures similar to those used in the analysis of gestation length showed that both male and female calves resulting from the first gestations were significantly smaller than for later calves at all stations. The differences in birth weight between other gestations were not significant. The effect of age of dam was similar in all breed groups. Birth weights were adjusted to a mature dam basis within sex using the same methods for adjustments of gestation length.

Sex, sires within breeds and the interaction of sex and sire were significant in all groups but the interaction of sex and breed was not. After adjustment for age of dam, sex and sire effects, breed differences were found to be significant ($P<.01$) at all stations. Crossbred calves from Jersey dams were heavier than purebreds from the same dams (table 2). The $F_1$ crossbred dams gave birth to heavier calves when backcrossed to Jerseys than when backcrossed to Sindhis.

A covariance analysis was made to determine the extent to which birth weights were influenced by gestation length. Breed differences, after adjustment for the regression of birth weight on gestation length, were significant ($P<.01$). This analysis indicates there are factors other than gestation length that influenced birth weights. The differences between regression coefficients between herds and between breed groups within herds were not significant. The average birth weights, adjusted to a common gestation length, are shown in table 3.

TABLE 3. BIRTH WEIGHT MEANS OF OFFSPRING FROM JERSEY AND $F_1$ COWS ADJUSTED TO A COMMON GESTATION LENGTH

| Herd | Jersey | ¾ J | $F_1$ | ¼ J |
|---|---|---|---|---|
| | lb. | lb | lb. | lb. |
| Beltsville | 62.2 | 61.7 | 69.2 | 54.3 |
| Jeanerette | 59.4 | 60.3 | 63.9 | 55.9 |
| Tifton | 56.9 | 65.7 | .... | .... |

The $F_1$ calves showed heterosis for birth weight in both the Beltsville and Jeanerette herds even after adjustment for gestation length. The ¾ J calves were heavier than Jerseys but this appears to have been due primarily to increased gestation length. Even though the $F_1$ cows were about the same size as Jerseys, the ¼ J calves were smaller than any of the other groups and the differences were more pronounced when gestation length was considered. The ¼ J calves, however, averaged 10 to 15 pounds heavier than the weights reported for purebred Sindhis in India (Joshi and Phillips, 1953; Rathore, 1949; Saxena, 1950).

The pattern for breed effects was similar at all stations, but there were variations in the amount of change in the breed groups. Although the

TABLE 4. MONTHS OF AGE AT FIRST AND SECOND CALVING, AVERAGE DAYS FROM FIRST BREEDING TO CONCEPTION AND SERVICES PER CONCEPTION

| | First calving | | | | Second calving | | | |
|---|---|---|---|---|---|---|---|---|
| Breed group | No. | Age | 1st breeding to conc. | Ser./ conc.[a] | No. | Age | 1st breeding to conc. | Ser./ conc.[a] |
| | | mo. | days | | | mo. | days | |
| | | | | Beltsville | | | | |
| Jersey | 68 | 26 | 39 | 2.15 | 62 | 40 | 25 | 1.74 |
| ¾ J | 15 | 26 | 42 | 1.49 | 3 | 40 | 22 | 1.33 |
| $F_1$ | 43 | 26 | 20 | 1.70 | 28 | 41 | 19 | 1.41 |
| ¼ J | 18 | 27 | 35 | 1.78 | 8 | 41 | 12 | 1.56 |
| | | | | Jeanerette | | | | |
| Jersey | 90 | 28 | 22 | 1.40 | 77 | 42 | 21 | 1.67 |
| ¾ J | 10 | 30 | 29 | 1.40 | 7 | 43 | 20 | 1.43 |
| $F_1$ | 48 | 28 | 15 | 1.33 | 39 | 42 | 8 | 1.34 |
| ¼ J | 16 | 29 | 13 | 1.38 | 6 | 43 | 10 | 1.50 |
| | | | | Tifton | | | | |
| Jersey | 41 | 25 | 27 | 1.73 | 39 | 37 | 18 | 1.47 |
| ¾ J | 21 | 26 | 17 | 1.48 | 9 | 37 | 5 | 1.22 |

[a] Weighted average.

cause of these variations is unknown, the difference in the $F_1$ groups appears to reflect environmental effects to some degree whereas variations in the ¾ J groups seem to be due to the effects of gestation length and sire.

At Beltsville and Jeanerette, where the ¾ J crosses were produced by mating $F_1$ males to Jersey females as well as the reciprocals, the ¾ J calves sired by the $F_1$ males were significantly heavier (63.7 lb.) than the ¾ J calves sired by Jersey bulls (57.2 lb.). The reason the ¾ J calves at Tifton were larger than at the other stations is not known.

*Age at First Calving.* The primary interest in this case was to determine if any of the combinations of the two breeds affected sexual maturity to the point that it delayed the age of first calving. The average age for first and second calvings, the average days from first breeding to conception and services required for conception in the first and second breeding periods are shown in table 4. Within station, the average age of first and second

calvings were very similar for all breed groups. The more advanced ages of the Jeanerette groups were due to an older age of first breeding as indicated previously. There was some variation within stations among breed groups in days from first breeding to conception, but only the difference between Jerseys and $F_1$ groups at Beltsville was significant. There was also some variation in services per conception, but none of the differences between breed group means was significant. The variation shown for these factors could be attributed primarily to sire effects as there were highly significant differences between sires.

Since observations for first estrus commenced three months prior to expected breeding age, a further study was made to determine the average age of the first recorded behavioral estrus in the groups in the Beltsville and Jeanerette herds. The groups means are shown in table 5. In the Beltsville herd, where observations for estrus were commenced at 12 months of age, the Jerseys and ¾ J groups averaged about 400 days, the $F_1$ averaged 418 days and the ¼ J, 444 days. The difference between the

TABLE 5. MEAN AGE OF FIRST OBSERVED ESTRUS IN THE BELTSVILLE AND JEANERETTE HERDS

| | Jersey | | ¾ J | | $F_1$ | | ¼ J | |
|---|---|---|---|---|---|---|---|---|
| Herd | No. | Mean | No. | Mean | No. | Mean | No. | Mean |
| | | days | | days | | days | | days |
| Beltsville | 77 | 404± 2.9 | 22 | 397± 5.5 | 49 | 418±5.3 | 24 | 444± 7.9 |
| Jeanerette | 52 | 497±12.6 | 16 | 497±26.8 | 46 | 485±9.6 | 16 | 533±21.9 |

Jersey and ¾ J means was non-significant but the $F_1$ mean was significantly different ($P<.01$) from the Jersey mean. The differences between the $F_1$ and ¼ J means were also significant ($P<.01$). Estrus has been observed in another study at Beltsville in the Jerseys, ¾ J and $F_1$ as early as 9 months of age but has never been observed in the ¼ J until after one year of age.

At Jeanerette the $F_1$ crosses had the lowest mean for days of first recorded estrus, the Jersey and ¾ J were intermediate and the ¼ J averaged somewhat older. The pattern for the ¼ J group was similar to that in the Beltsville data. In the Jeanerette data environmental variation may have been a factor in making the standard errors large and breed effects non-significant.

From this study it is evident that up to 75% Sindhi inheritance did not materially affect reproductive performance in these herds. There are some indications, however, that increasing Sindhi inheritance did tend to retard age of sexual maturity, although the effect was not nearly as evident as that reported by Tandon (1951).

Sundaresan *et al.* (1954) and Tandon (1951) reported that when breeding was commenced at the first estrus, the average age of first calving of

purebred Red Sindhis was about 41 months. Five purebred Sindhis at Jeanerette averaged 37 months of age at first calving and 790 days at first observed estrus which agreed with these reports. The results of this study tend to support the view of Tandon (1951) in that the rate of sexual maturity with changes in Sindhi inheritance does not appear to be entirely additive.

## Summary

Data from the Red Sindhi-Jersey crossbreeding investigations conducted at three stations were studied to determine the possible effects of varying degrees of Sindhi inheritance on gestation length, birth weight and age at first calving.

Each 25% of Sindhi inheritance increased gestation length approximately three days, thus suggesting an additive genetic effect. Parity of calving, sires within breeds and interaction of sire and sex had a significant effect on gestation length but sex differences were not significant.

Gestation length, age of dam, sires within breeds and the interaction of sex and sire had significant effects on birth weight. The interaction of sex and breed was not significant. The $F_1$ crossbred calves showed heterosis for birth weight even after adjustment for gestation length. The ¾ J calves were heavier at birth than Jerseys but this might be attributed primarily to increased gestation length. The ¼ J crossbred calves were generally smaller than any of the other groups and the differences were more pronounced when gestation length was considered.

The results of this study indicate that up to 75% Sindhi inheritance may be used in combination with Jerseys without delaying the age of first calving beyond that normally considered satisfactory for purebred Jerseys.

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# EVALUATION OF THE X-RAY METHOD OF DETECTING ANIMALS HETEROZYGOUS FOR SNORTER DWARFISM [1, 2]

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THIS paper deals with the type of dwarfism first described by Johnson *et al.* (1950). These dwarfs are usually referred to as "Snorter" dwarfs because they usually manifest a breathing difficulty. "Snorter" dwarfism has become a major problem in many beef herds. These dwarfs are almost a total loss to the breeder since many die at birth and those that do live rarely attain a desirable market weight or finish. Most "Snorter" dwarfs are very susceptible to bloat and sooner or later succumb to this condition. Perhaps the greatest loss to the purebred breeder arises from the reflection cast on his herd as a source of seed stock.

Data presented by Johnson *et al.* (1950) Lush and Hazel (1952, 1955), Gregory *et al.* (1951) and Pahnish *et al.* (1955), indicate "Snorter" dwarfism is inherited as a simple recessive gene. Assuming a simple recessive as the mode of inheritance, cattle can be of three genotypes as follows:

1. Non-carriers (homozygous for the normal allele of the dwarf gene)
2. Carriers (heterozygotes)
3. Dwarfs (homozygous for the recessive dwarf gene)

The heterozygotes are apparently normal phenotypically.

Emphasis in research has been on finding some method of identifying carriers at early ages. For the past four years the University of Tennessee, in cooperation with Iowa State University, has investigated an X-ray method of making this identification. This paper presents a summary of this work.

## Experimental Procedure

Radiographs were made of the lumbar vertebrae (lateral view) of young calves usually before they reached two weeks of age. The study included over 1500 purebred and grade Hereford, and purebred Angus calves from herds located at the main station (Knoxville) and six sub-stations located in Middle and East Tennessee. Approximately 20 herds were represented for a three-year period and three of these herds for four years. Several

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[3] Department of Animal Husbandry-Veterinary Science.

different lines of breeding of both the Hereford and Angus breeds were represented.

The radiographs were made with a mobile X-ray unit with a 100 milliampere, 100 kilovolt capacity. Fast speed cassettes, a cone, and stationary grid were used. In making the exposures, tube to target distance, milliampherage and time of exposure were held constant. The kilovoltage was varied according to the loin width of the calf, usually within the range of 60 to 80 kv. The variables involved in making radiographs under field conditions make it rather difficult to make readable radiographs consistently. Therefore, two or more radiographs were made on each calf.

Radiographs were classified with respect to morphology of the lumbar vertebrae similar to a method described by Emmerson and Hazel (1956). By this method animals with normal vertebrae were classified as C. Animals with extremely abnormal vertebrae (typical of dwarf calves) were classified as A. Animals with vertebrae morphology ranging between C and A were classified B. The B classification was divided into seven sub-groups, $B_2$ through $B_8$. $B_2$ vertebrae were slightly abnormal and approached the normalcy of C-type vertebrae. $B_8$ vertebrae had extreme abnormality approaching that of typical dwarf vertebrae. Examples of C, B, and A-type vertebrae are given in figure 1.

The ventral profile (lateral view) of normal or C-type vertebrae had a smooth concave appearance with well defined convex lobes at each end. The ventral lobes of each vertebrae were symmetrical or nearly so. In comparison with C-type vertebrae, the body of the dwarf or A-type vertebrae was smaller in relation to the epiphyses. Very pronounced double peaked calcium deposits on the ventral outline of the vertebrae body were characteristic of all six lumbar vertebrae of dwarfs. The B-types of vertebrae ranged in morphology between these two extremes. In most cases animals with B-type radiographs had one or more vertebrae with small irregular calcium deposits on the ventral surface. In addition, the ventral lobes of abnormal vertebrae were usually less prominent and in many cases unsymmetrical.

The variation between adjacent classifications appeared continuous from C through $B_8$. The only break observed between adjacent classifications was between $B_8$ and A. Some 40 dwarfs were X-rayed and, with one exception, their vertebrae were easily distinguished from those of the most extreme B-type vertebrae. The one exception had a $B_8$ classification.

Each radiograph was classified by two or more persons working independently. However, to simplify the data for analysis, one classification for each calf was agreed on collectively. The classification system was subjective. However, when a sample of radiographs from this station was also classified by workers of Iowa State University, general agreement was observed between the two classifications.

At the time the X-ray work was started at this station, no young animals known to be carriers were available. Therefore, in order to estimate the

accuracy of the X-ray method, some of the X-rayed animals were progeny tested to establish their genotype with respect to dwarfism. Nine bulls (4 C-type and 5 B-type) X-rayed as calves were mated to carrier cows. Seven bulls were mated each to a total of 10 cows over a period of 3 years. Two bulls proved to be carriers from fewer matings.

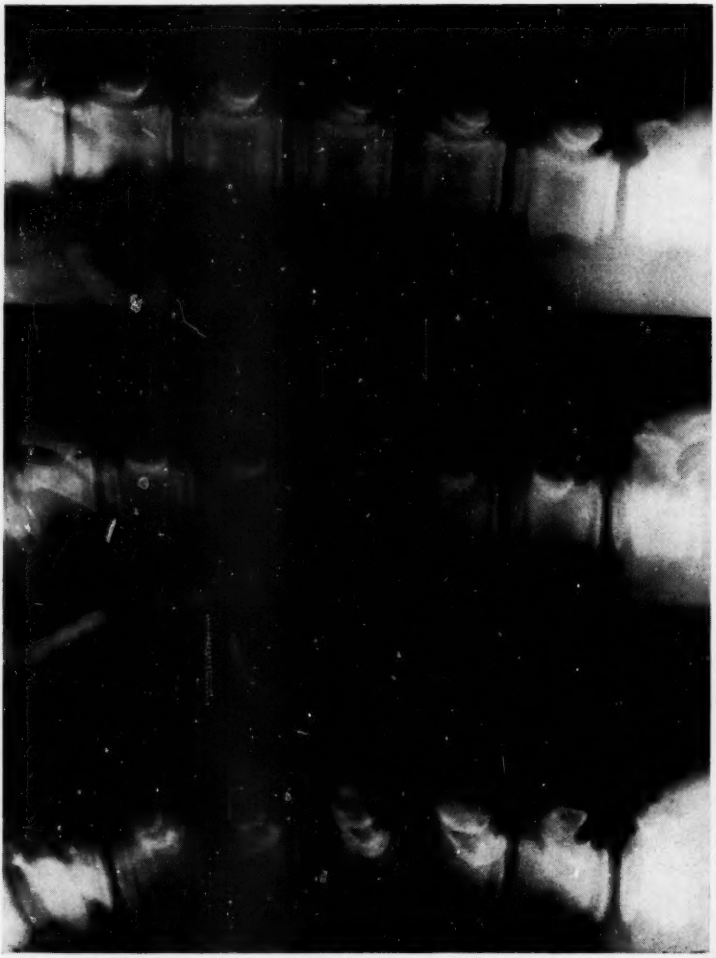

**Figure 1. The top vertebrae is "C" type, the middle vertebrae "B" type and the lower vertebrae "A" type. All calves were less than two weeks of age when X-rayed.**

In addition to the progeny test of bulls, 92 yearling heifers X-rayed as calves were mated to dwarf bulls. Fourteen of these yearlings were mated again as two-year-olds. Thirty-three of these heifers were by carrier sires and out of cow herds estimated to be approximately 20% carriers. Eleven heifers were sired by a pedigree-clean bull but were out of cows that had carrier sires. The remaining 48 heifers were produced from pedigree clean matings.

These heifers were pasture bred to four dwarf bulls. Three were Hereford and the other an Angus-Hereford crossbred. The crossbred sired approximately 70% of the calves.

TABLE 1. SUMMARY OF CALVES X-RAYED 1954–57

| Dwarfism status of bull | Percent of carrier cows in herds | No. of calves | X-ray classification (percent of total) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | C | $B_2$ | $B_3$ | $B_4$ | $B_5$ | $B_6$ | $B_7$ | $B_8$ | A |
| | | | | | | Hereford | | | | | |
| Carrier | 32[a] | 336 | 19.0 | 35.7 | 17.3 | 10.4 | 5.7 | 1.5 | 1.5 | 1.2[b] | 7.7 |
| Unknown[c] | 0–40 | 643 | 39.5 | 32.0 | 13.2 | 5.6 | 4.8 | 2.3 | 1.6 | 0.9 | ... |
| Ped. clean | Ped. clean | 210 | 61.0 | 27.1 | 7.6 | 2.9 | ... | 1.0 | 0.5 | ... | ... |
| | | | | | | Angus | | | | | |
| Unknown[d] | Unknown | 239 | 52.3 | 32.2 | 10.0 | 4.6 | 0.8 | ... | ... | ... | ... |

[a] Approximated from the number of dwarfs produced.
[b] One dwarf.
[c] A few of these bulls were pedigree clean.
[d] Presumed non-carrier.

## Results and Discussion

In table 1 is summarized the distribution of X-ray classifications in each of four groups according to the dwarfism status of the parents. The distribution of each classification is expressed as a percentage of the total for the group. This table does not include the progeny from test matings and a few miscellaneous calves. Considering only the progeny of bulls that proved to be carriers, 27 of 336 calves were dwarfs (one calf classified as $B_8$ was a dwarf). With the exception of one herd, the calves in this group were one year's progeny of the herds represented. From the number of dwarf calves dropped, the cow herds were estimated to have been 32% carriers. Based on parental genotypes, the expected ratio of carrier to non-carrier calves was 171:138. Under the hypothesis that carriers were B-type and non-carriers C-type, the observed ratio of carrier to non-carrier calves was 245:64. The difference between the observed ratio and the expected ratio was highly significant. However, this varied from herds that approached the expected ratio to herds that had almost all B-type calves.

The second group of progeny in table 1 was produced from Hereford matings in which either the cow herds, or the bulls mated to them or both

had "dirty" (one or more carrier ancestors two or less generations removed) pedigrees. The progeny of 41 bulls, 19 of which were pedigree clean, are represented in this group. The estimated frequency of dwarf carriers among the cow herds varied from no carriers to as high as 40% carriers. The herds in this group include many of the same herds also in group one but mated to different bulls. Since the actual dwarfism status of most bulls and many of the cows was unknown, the accuracy of the X-ray cannot be evaluated. However, in general as the estimated frequency of dwarf carriers in the cow herds became smaller so did the percentage of their offspring classified as B. Again, this varied among herds.

The third group of progeny shown in table 1 was produced from matings of pedigree clean Herefords. The distribution of the X-ray classification among the progeny of these matings gives some indication of vertebrae abnormality that might be expected among normal (dwarf free) Hereford calves. Again, the percentage of calves classified as B varied among herds. However, only 1.5% (3 of 210) of the progeny from these matings had vertebrae with higher than mild abnormality ($B_1$) classifications. The differences between frequency distributions of the X-ray classifications of progeny from group one and group three matings indicate a general relationship between vertebrae abnormality and the dwarf gene. However, these data also indicate that mild abnormalities are not necessarily associated with the dwarf gene.

The fourth group of progeny (table 1) was produced by presumed dwarf-free Angus matings. Considerable inbreeding has been carried out in these herds for a number of years and no dwarfs have been produced. A comparison of the X-ray classifications of the Angus calves with those of the pedigree clean Herefords indicate the X-ray method is slightly more accurate in predicting the genotypes of the latter. As was true with the pedigree clean Hereford calves, the vertebrae abnormalities that occurred among the Angus calves were mild.

Giving the various X-ray classifications a numerical value (C=1, $B_2$=2, $B_3$=3, etc.), the average X-ray classification of 765 male calves, exclusive of dwarfs, was 2.43. The average of 790 female calves was 1.97.

*Test Matings.* In table 2 are given the results on progeny of nine X-rayed bulls mated to carrier cows Bulls 424 and 434 were sired by a pedigree clean bull and out of cows that were sired by a carrier bull. The remaining bulls were sired by carrier bulls and out of cow herds that were estimated to be 20–25% carriers. Bulls 459 and 637 proved to be carriers from matings to four carrier cows each. The remaining seven bulls were mated to approximately 10 carrier cows each over a period of three years. At the present level of testing three out of five B-type bulls or all three B-type bulls having a carrier sire have proved to be carriers. None of the C-type bulls (all of which have carrier sires) have produced dwarfs.

The cows mated to these bulls were pregnancy checked each year. Over a three-year period, approximately 85% of these cows were diagnosed as

TABLE 2. PROGENY OF X-RAYED BULLS MATED TO KNOWN CARRIER COWS

| Bull no. | X-ray type of bull | Progeny | |
|---|---|---|---|
| | | No. of calves | Phenotype |
| 274 | C | 5 | Normal |
| 334 | C | 6 | Normal |
| 455 | C | 9 | Normal |
| 451 | C | 5 | Normal |
| 114 | $B_4$ | 8 | 1 dwarf |
| 424 | $B_3$ | 6 | Normal |
| 434 | $B_3$ | 6 | Normal |
| 459 | $B_4$ | 3 | 1 dwarf |
| 637 | $B_5$ | 4 | 2 dwarfs |

pregnant each fall; yet over the same period of time these cows have had an average calving percent of approximately 65. These cows have been under close surveillance and no occurrences of abortion have been reported.

In table 3 are given the X-ray classifications of the progeny from matings of Hereford heifers to dwarf bulls. The X-ray classifications of the progeny are summarized according to the X-ray classification of the dam and the dwarfism status of her sire. The vertebrae abnormalities of the tested heifers ranged from C through $B_4$. At the time these tests were made, heifers with vertebrae abnormality more extreme than $B_4$ were not available.

TABLE 3. SUMMARY OF X-RAY CLASSIFICATION OF CALVES [a] SIRED BY DWARF BULLS

| X-ray classification of dam | Dwarfism status of dam | Total no. of progeny | X-ray classification of progeny | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | C | $B_2$ | $B_3$ | $B_4$ | $B_5$ | $B_6$ | $B_7$ | $B_8$ | A |
| C | Carrier sire | 7 | 2 | 2 | .. | 2 | .. | .. | .. | .. | 1 |
| $B_2$ | Carrier sire | 26 | 2 | 7 | 3 | 2 | 2 | 1 | 2 | .. | 7 |
| $B_3$ | Carrier sire | 4 | .. | 2 | 1 | .. | 1 | .. | .. | .. | .. |
| $B_4$ | Carrier sire | 3 | .. | .. | .. | 1 | 1 | .. | 1 | .. | .. |
| | | 40 | 4 | 11 | 4 | 5 | 4 | 1 | 3 | .. | 8 |
| C | Carrier grand sire | 1 | 1 | .. | .. | .. | .. | .. | .. | .. | .. |
| $B_2$ | Carrier grand sire | 3 | .. | 2 | .. | .. | .. | .. | .. | 1 | .. |
| $B_3$ | Carrier grand sire | 2 | .. | .. | .. | 1 | 1 | .. | .. | .. | .. |
| $B_4$ | Carrier grand sire | 1 | .. | 1 | .. | .. | .. | .. | .. | .. | .. |
| | | 7 | 1 | 3 | .. | 1 | 1 | 2 | 2 | 1 | .. |
| C | Ped. clean | 18 | 5 | 7 | 1 | 1 | 2 | 2 | .. | .. | .. |
| $B_2$ | Ped. clean | 9 | 3 | 2 | 2 | 1 | 1 | .. | .. | .. | .. |
| $B_3$ | Ped. clean | 5 | 1 | 3 | .. | 1 | .. | .. | .. | .. | .. |
| $B_4$ | Ped. clean | 1 | .. | 1 | .. | .. | .. | .. | .. | .. | .. |
| | | 33 | 9 | 13 | 3 | 3 | 3 | 2 | .. | .. | .. |
| Summary of all groups | | 80 | 14 | 27 | 7 | 9 | 8 | 3 | 3 | 1 | 8 |

[a] Most of these calves were sired by a crossbred Hereford-Angus dwarf bull.

One heifer with C-type vertebrae produced a dwarf calf. This heifer was 21 days of age when X-rayed. Previous work at this station (High *et al.*, 1956) indicates that as a calf becomes older, mild vertebrae abnormalities present at birth tend to disappear. If this heifer had been X-rayed earlier, she might have shown some vertebrae abnormality.

No dwarfs were produced by pedigree clean heifers with B-type classifications. The absence of dwarf progeny from these matings indicates that at least some heifers with B-type radiographs were not carriers.

Since the progeny of the heifers shown in table 2 were all sired by dwarf bulls, every calf would carry at least one dwarf gene and normal calves (phenotypically) were presumed to be carriers. Of the 72 normal calves (definitely not dwarf phenotype) produced, 14 had normal (C-type) vertebrae. Seven were males and seven were females. Apparently carrier calves of both sexes may have normal appearing radiographs.

The 1957 and 1958 calves of 21 pedigree clean Hereford females were X-rayed. The 1957 calves were by dwarf bulls and the 1958 calves were by pedigree clean Hereford bulls. With three exceptions the vertebrae of the 1957 progeny were more abnormal than those of their 1958 half-sibs. In two comparisons the vertebra abnormality of both offspring appeared the same. In one comparison the vertebrae of the 1957 offspring were more nearly normal than those of the 1958 half-sib. In most comparisons between maternal sibs the differences in vertebrae morphology were small. However, the 1957 calves averaged one classification higher (more abnormal) that the 1958 calves.

TABLE 4. TESTED PROGENY OF CARRIER BULLS

| X-ray classification of progeny | Number of progeny | Number proven carriers | Theoretical number of carriers not yet found |
|---|---|---|---|
| C | 10 | 1 | 0.90 |
| B | 29 | 10 | 9.10 |

The progeny test information on animals sired by carrier bulls is summarized in table 4. Included are 32 heifers mated to dwarf bulls and seven yearling bulls mated to carrier cows. At the present level of testing 1 of 10 C-type and 10 of 29 B-type have proven to be carriers. Approximately 53% of the 39 animals tested were estimated to be carriers, since they were produced from matings of carrier bulls to cow herds that included approximately 20–25% carriers. The theoretical number of carriers not yet found were estimated from parental genotypes using the C to B ratio of those already proven carriers.

*Evaluation of X-ray Method.* Based on these data, the X-ray method may be evaluated as follows:

1. Of 83 carriers produced by using a dwarf parent, or proven to be a carrier by a progeny test, 68 or 82% were classified as B-type.

2. Of 210 progeny produced from presumed non-carrier (pedigree clean) Hereford matings, 61% were classified as C-type. This varied a great deal among herds depending on their genetic make-up. The X-ray method appeared less accurate in predicting the genotype of Angus progeny.

3. The X-ray method has been very accurate in identifying "Snorter" dwarfs. Of some 40 "Snorter" type dwarfs that have been X-rayed, all have had extremely abnormal vertebrae, and, with one exception, all were classified A. The one exception had a $B_8$ or extreme carrier classification.

From progeny tests:

4. Approximately 81% of the animals with C-type vertebrae are really non-carriers. This estimate is based on the one proven carrier and the theoretical 0.90 carriers not yet found of 11 animals classified as C's (see table 4).

5. Approximately 66% of the animals with B-type vertebrae are really carriers. This estimate is based on the 10 proven carriers and the theoretical 9.10 carriers not yet found of 29% of the animals classified as B's (see table 4).

## Summary and Conclusions

For the past 4 years the X-ray method of detecting animals heterozygous for "Snorter" dwarfism has been investigated. This method is based on vertebrae abnormalities as shown on radiographs of young calves. This study includes the radiographs of some 1500 calves representing several different lines of breeding in both the Hereford and Angus breeds. Also, included in this study are the test mating results of 89 animals (80 heifers, 9 bulls) X-rayed as calves.

The data presented indicate:

1. The X-ray method is highly accurate in identifying "Snorter" dwarf calves.

2. There is considerable overlap within the range of normal morphology to mild vertebrae abnormality between presumed non-carrier and carrier animals.

3. Radiographs of a bull's progeny may be used as a general method of predicting his dwarfism status before actually progeny testing him. However, the X-ray method is not recommended to the breeder as a basis for identification of individual animals with respect to genotype for dwarfism.

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# AN IMPROVED RANGEMETER FOR SHEEP [1]

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THE first rangemeters were developed by Cresswell (1957) at Massey College, New Zealand, to study distances traveled by Romney Marsh and Cheviot ewes when they grazed on hills and low land pastures. In developing the rangemeter for measuring sheep activity as expressed in miles per day, certain difficulties were considered: (1) It is necessary to measure the distance traveled by animals under natural conditions of pasture terrain which may include hill pastures, lowland pastures, mountain pas-

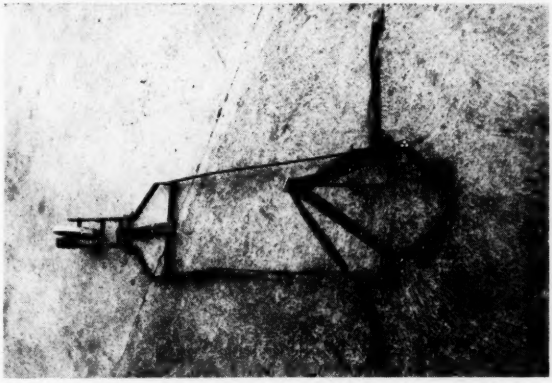

**Figure 1. The rangemeter as developed at Massey College, New Zealand.**

tures, desert range pastures, or cultivated pastures; (2) radio tracking, pedometers, and other such devices for tracking movement are too complicated or inaccurate to use on the grazing sheep. Cresswell (1958) has reviewed the literature on the various techniques of measuring the distances traveled by grazing sheep.

The purpose of this report is to describe an improved rangemeter and to present data on the distance traveled by Rambouillet, Columbia, and Hampshire ewes.

## Materials and Methods

The rangemeter consists of a lightweight harness, two metal shafts, and a chassis which, sprung onto the ground, carries a small land wheel to motivate an automatic mileage recorder (a Lucas Cyclometer) [4] as used on

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bicycles. The total weight of the machine is 8 lb., but the sheep carried only 1 lb. or one-half the spring loaded weight of the shafts which are at the one end pivoted on the shoulder harness and at the other skidded on the ground. The draught of the machine is exceedingly light, a pull of approximately 1 lb. being sufficient to move it on flat and hilly terrains.

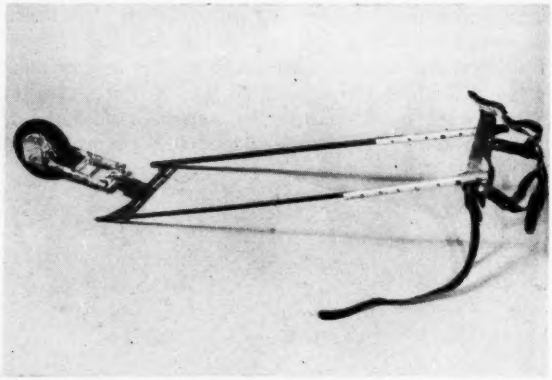

**Figure 2. The improved rangemeter showing all steel, welded construction, with telescope shafts.**

Figures 1 and 2 illustrate the old and new rangemeter. The important differences between the two models are:

| New Zealand Model<br>Figure 1 | Utah State University Model<br>Figure 2 |
|---|---|
| 1. Strip steel shafts extendable only by plate coupling (cumbersome and time-consuming in adjustment). | 1. T-bar shafts (mild steel) with tubular rider which allows rapid adjustment to length. Width is adjusted by bending the shafts. |
| 2. All-riveted construction (the rivets tend to work loose). | 2. All-welded construction. |
| 3. Leather spring (required frequent adjusting and tended to rot). | 3. Coiled steel spring clear of the terrain. |
| 4. Hard steel bushing for wheel shaft (tended to wear, thus allowing the development of lash in the wheel and damage to the recorder). | 4. Ball-bearing axle. |
| 5. Wooden wheel (superior to the rubber tire. The rubber tires tend to pick up field debris while the wooden wheels maintain themselves clean). | 5. Rubber-tired, steel wheel. |

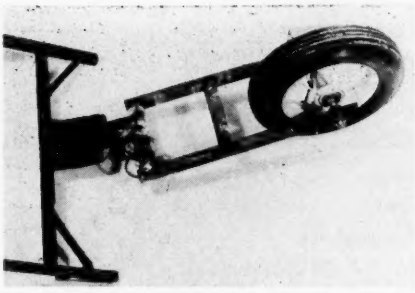

**Figure 3. Detail of construction of wheel assembly.**

The ultimate wheel development will probably be a hollow wooden wheel with the recorder mounted inside to give it complete protection. This is being investigated. Figure 3 gives the detail of construction of the wheel assembly. Figure 4 shows the rangemeters on a group of ewes.

To test the improved rangemeter, four Hampshire ewes and four Rambouillet ewes were fitted with machines and grazed in a 2.5 acre pasture. After a week of training, records were taken beginning August 14, 1958. On September 20, four Columbia ewes were added. The pasture was increased to 5 acres on September 29. It was not possible to obtain one large pasture. The gate was left open between two small pastures. The sheep were observed to graze by routine in the two areas.

## Results and Discussion

The distance traveled by the Rambouillet, Hampshire, and Columbia ewes when in pasture of two sizes are shown in figure 5. The mileage records

**Figure 4. Rangemeters attached to ewes.**

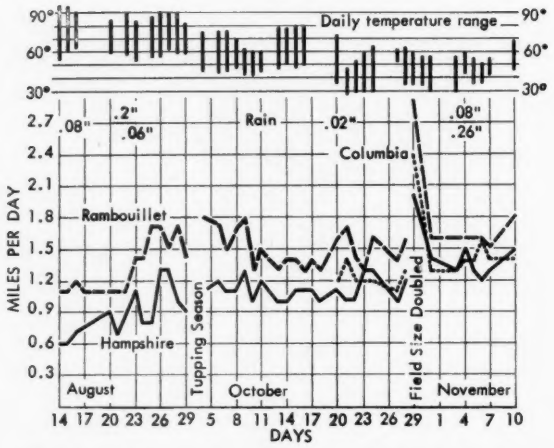


**Figure 5. The mean mileages of Rambouillet, Columbia, and Hampshire ewes (groups of four) under varying season and pasture regimes.**

are the means for four ewes of equal ages, 1 to 3 years, for each of the four breeds. Records were taken every day at 1 p.m. when the sheep were carefully gathered to a set of small field pens. The sheep quickly adapted themselves to the routine. In gathering the ewes, it was necessary to drive them slowly for about 160 to 180 yards to the field pens. Absolute mileages would be approximately 1/10 mile less per day than the means shown in figure 5, but no correction was deemed necessary in presenting the results of this comparative study.

It will be seen that (1) the Rambouillet is approximately 25% more active (in distance traveled) than the Hampshire; (2) the Columbia probably fits in somewhere between the Rabouillet and the Hampshire; (3) there is a tendency to increase activity as tupping time approached; this was very apparent in the New Zealand studies (Cresswell, 1958); (4) there was no noticeably increased activity between August when the irrigated pastures were lush and October-November when the grass became progressively less in quantity until the fields were quite bare; (5) seasonal and daily temperature changes had no regular effect on the daily mileage, and (6) rain (admittedly almost negligible in quantity) had no regular effect on the daily mileage. A striking fact was the frequency with which individual sheep maintained their daily mileages to within 1/10 mile.

In a long-term study, Cresswell (1958) found Cheviot ewes traveled much farther than Romney Marsh ewes on New Zealand hill country, although on flat land the Romney was almost as active as the Cheviot. The

data reported here also show that different breeds of sheep travel different distances. This difference between breeds indicates that certain breeds may be better adapted than others to travel. It may be that the energy requirement for voluntary activity (energy expended in obtaining food and drink) is different for various breeds of sheep.

Rangemeters have been supplied to the U.S.D.A. and several State Colleges.

## Summary

An improved rangemeter for sheep was developed. It consists of a harness, two metal shafts, a wheel, and automatic mileage recorder.

Four ewes of each of three breeds, Rambouillet, Columbia, and Hampshire were fitted with rangemeters. It was found that Rambouillet ewes travel about 25% farther than Hampshire ewes, and Columbia ewes appear to travel slightly farther than Hampshire ewes in the same size pasture.

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# SELECTING YEARLING RAHMANI SHEEP

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THE most efficient method of selection is that which results in the maximum genetic improvement per unit of time and effort expended (Hazel and Lush, 1942). They found that the total score method or index was most efficient. Hazel (1943) outlined the method for constructing selection indexes. Hazel and Terrill (1946) presented an index for selecting Rambouillet lambs. Karam *et al.* (1953) suggested an index for farm flock lambs.

The purpose of the present study was to construct an index for selecting yearling Rahmani sheep, rams and ewes, for replacements. At present, the most important traits to consider are body weight, fleece weight and type of birth (litter size). They all have a direct effect on income from the sheep enterprise, i.e. meat and wool. There are other traits such as market grade, staple length and wool grade but they are not expected to be of economic importance until there is a demand for them by the consumer and the industry.

There are several constants which must be obtained and used in constructing the index. They are the relative economic value for each trait, the phenotypic and genetic variances, and the phenotypic and genetic covariances between traits.

## Materials

The data used in the present study were taken from the records of Rahmani sheep kept on the Experimental Farm of the College of Agriculture from 1943 to 1956. The sheep were fed on Berseem (*Trifolium Alexandrinum*) from November until May. During the summer they grazed in the fields on waste feeds and were given a concentrate supplement consisting of one part undecorticated cottonseed cake to one part rice bran.

## Results

*The Economic Values.* The economic value of a trait is defined as the relative effect of a unit change on net profit. Any increase in the cost of production due to that extra unit should be considered. Karam (1957, 1959a) estimated the average lambing percentage among Rahmani sheep as 124% and the average lamb mortality, from birth up to 4 months of age, as 26.9%. Using an annual replacement rate of 20% one would expect a flock of 100 ewes to wean about 72.5 lambs each year.

The economic value of a unit change in yearling weight is a function of market price and the cost of production. Table 1 presents the average price of mutton over a period of 10 years from 1947 to 1956. Years prior to 1947 were still affected by Second World War conditions. The average price of 1 kilogram of mutton was 25 piasters. There is no information available on live weight prices. On the basis of an estimate (44%) for the dressing percentage of Rahmani sheep as reported by Badreldin (1951) the average price of 1 kilogram of sheep would be about 11 piasters.

TABLE 1. THE AVERAGE PRICES OF WOOL AND MUTTON ACCORDING TO CAIRO AND ALEXANDRIA MARKETS FOR THE YEARS 1947 TO 1956 (ANNUAL STATISTICS, MINISTRY OF FINANCE)

| | Piasters per pound for: | |
|---|---|---|
| Year | Mutton | Brown and black wool |
| 1947 | 10.08 | 7.97 |
| 1948 | 10.38 | 9.06 |
| 1949 | 10.45 | 9.12 |
| 1050 | 11.00 | 10.92 |
| 1951 | 12.55 | 12.77 |
| 1952 | 12.13 | 12.71 |
| 1953 | 11.30 | 11.52 |
| 1954 | 11.08 | 11.60 |
| 1955 | 11.14 | 13.17 |
| 1956 | 11.13 | 12.25 |
| Average | 11.12 | 11.11 |

Therefore the price of the extra kilograms of sheep sold each year would be 7.98 pounds. In Egypt mutton prices are almost the same as lamb prices and mutton conformation has little or no economic value. The cost of maintaining an extra kilogram of body weight in a flock of 100 ewes from the end of the Berseem season until the new Berseem is available will not be more than 3.08 pounds. This was based on the assumption that one animal consumes (per day) an amount of feed worth an average of one piaster. Such feeds are usually given to sheep in the dry lot. The maintenance cost while on Berseem was negligible. There will be no extra charge for shipping since it is usually done on a per head basis. Therefore the economic value of a 1 kilogram change in yearling body weight is about 4.90 pounds.

About 117 lambs would be weaned every year if each lambing ewe in the flock had a twin. This means 44.5 more lambs. A twin lamb averages about 35 kilograms by the time it is 12 months old (Karam, 1959b). On the basis of the previous discussion its value will be 3.85 pounds and the cost of maintenance about 2.41 pounds. Ten more piasters should be subtracted for handling and shipping charges, leaving 1.34 pounds as the

TABLE 2. PHENOTYPIC VARIANCES AND COVARIANCES

| Item | Yearling weight[a] | Fleece weight[a] | Type of birth |
|---|---|---|---|
| Yearling weight | 36.99 | 0.55 | —.39 |
| Fleece weight | | 0.08 | —.02 |
| Type of birth | | | 0.12 |

[a] Recorded in kilograms.

economic value of an extra twin born lamb or 60.73 pounds for the 44.5 lambs.

The average price of 1 kilogram of brown wool (since all Rahmani wool is brown) was 25 piasters (table 1). An extra kilogram of fleece will not increase shearing costs since it is done on a per head basis. The cost of maintaining an extra kilogram of fleece was assumed to be similar to that of maintaining a kilogram of mutton. Therefore, the net profit of a unit increase in fleece weight in a flock of 100 ewes was 15.06 pounds.

*Phenotypic Variances and Covariances.* The phenotypic variances and covariances required for the index are presented in table 2. The variances were obtained from earlier work published by the author (Karam, 1957, 1959b, 1959c). The covariances were calculated from the relationship $s_{x_i x_j} = r_{x_i x_j} s_{x_i} s_{x_j}$. The correlations were estimated within year and season as presented in table 3. Separate estimates are given for each sex. The correlations between body weight and fleece weight of rams and ewes were similar and therefore were pooled (0.32). This was used in obtaining the covariance. Morley (1950) found, in Merino sheep, that the correlation between grease fleece weight and body weight was 0.30. Terrill *et al.* (1950) reported an estimate of 0.54 for the correlation of the same traits in range Rambouillet rams.

Twin born lambs are usually lighter in weight and shear lighter fleeces than singles. This was true of the correlations obtained for ewes. Those of rams were small and insignificant. One was —.10 and the other +.10. The extra care and feed which ram lambs usually receive might be the cause of such low estimates. Therefore, only the correlations obtained for ewes were used in calculating the covariances needed.

TABLE 3. PHENOTYPIC CORRELATIONS AMONG TRAITS

| Traits correlated | Number of animals | r |
|---|---|---|
| Body wt. and fleece wt. of rams | 166 | 0.34±.07 |
| Body wt. and fleece wt. of ewes | 190 | 0.28±.07 |
| Body wt. and type of birth of rams | 238 | —.10±.06 |
| Body wt. and type of birth of ewes | 193 | —.15±.07 |
| Fleece wt. and type of birth of rams | 218 | 0.10±.07 |
| Fleece wt. and type of birth of ewes | 170 | —.14±.08 |
| Body wt. and type of birth produced by ewe | 193 | 0.23±.07 |
| Fleece wt. and type of birth produced by ewe | 170 | 0.05±.08 |

Table 3 also presents the correlations of body weight and fleece weight with type of birth produced by the ewe. They were 0.23 and 0.05, respectively. They were used in developing an index for ewes with one lambing record. Terrill and Stoehr (1942) found that ewes which were heavier as yearlings tended to wean more pounds of lamb per ewe year during their lifetime. The major part of the difference was due to more ewes lambing per ewe year and more lambs born per ewe lambing. The regression of pounds of lamb weaned per ewe year on pounds increase of fall yearling weight of the ewes was 0.49, 0.48 and 0.63 for Columbia, Corriedale and Rambouillet ewes, respectively. They also found that there was a slight advantage in lifetime average fleece weight in favor of heavier yearling ewes.

TABLE 4. GENETIC VARIANCES AND COVARIANCES

| Item | Yearling weight[a] | Fleece weight[a] | Type of birth |
|---|---|---|---|
| Yearling weight | 7.03 | 0.17 | 0.00 |
| Fleece weight | | 0.03 | 0.00 |
| Type of birth | | | 0.01 |

[a] Recorded in kilograms.

*Genetic Variances and Covariances.* Table 4 presents the genetic variances and covariances. The variances were estimated from the relationship $s_G^2 = h^2 s_x^2$, where $h^2$ is the heritability of the trait. Heritability estimates of yearling weight, fleece weight and type of birth were 0.19, 0.41 and 0.08, respectively (Karam, 1957, 1959b, 1959c).

The present set of data was not large enough to obtain reliable estimates of genetic covariances needed for the index. The genetic covariance between fleece weight and yearling weight was obtained from data presented by Morley (1950) on Merino sheep. The genetic covariance between fleece weight and type of birth was considered to be zero on the basis of the small and insignificant phenotypic correlation between the two traits (table 3). Also a value of zero was assigned to the covariance between body weight and type of birth. It is believed that the phenotypic correlation between them is mainly environmental.

*The Index.* Figure 1 is a path diagram illustrating the relationships among the traits considered in the present study. The aggregate genic value of an individual was defined as $H = a_1G_1 + a_2G_2 + a_3G_3$ where $G_1$, $G_2$ and $G_3$ are the genic values for yearling body weight, fleece weight and type of birth, respectively, and $a_1$, $a_2$ and $a_3$ are the relative economic values for these traits. Their phenotypes are included in the index which was defined by Henderson (1951) as:

$$I = a_1I_1 + \ldots + a_nI_n$$
$$= c_1x_1 + \ldots + c_nx_n.$$

$I_1, \ldots, I_n$ are indexes for estimating $G_1, \ldots, G_n$ utilizing information on the phenotypes of all traits $x_1, \ldots, X_n$. The advan-

tages of using this method of calculating the index were outlined by Karam *et al.* (1953).

The following three indexes were calculated and compared using the correlation between each of them and the aggregate genic value (H). The relative economic values used were 1.0, 3.1 and 12.3 for body weight, fleece weight and type of birth, respectively.

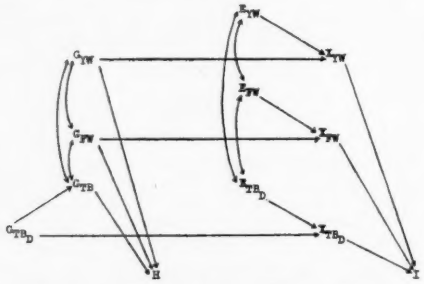

**Figure 1. Path diagram illustrating relationships among traits considered to have a direct effect on income in a Rahmani flock. $X_{YW}$, $X_{FW}$ and $X_{TB}$ are phenotypic expressions for yearling weight, fleece weight and type of birth (singles or twins). G's are genic values. E's are non-additive genetic effects plus environmental effects. H is aggregate genic value of the individual and I the selection index. Straight lines represent path coefficients and curved lines correlation coefficients.**

(1) includes body weight ($x_1$), fleece weight ($x_2$) and type of birth ($x_3$).

$$I=a_1I_1+a_2I_2+a_3I_3$$
$$I_1=.182\,x_1+1.064\,x_2+.770\,x_3$$
$$I_2=.000\,x_1+\ .395\,x_2+.063\,x_3$$
$$I_3=.000\,x_1+\ .009\,x_2+.044\,x_3$$
$$=x_1+13.1\,x_2+8.2\,x_3$$
$$r_{IH}=.456$$

(2) Includes body weight ($x_1$) and type of birth ($x_3$).

$$I=a_1I_1+a_2I_2+a_3I_3$$
$$I_1=.197\,x_I+.640\,x_3$$
$$I_2=.005\,x_I+.016\,x_3$$
$$I_3=.000\,x_I+.043\,x_3$$
$$=x_I+5.6\,x_3$$
$$r_{IH}=.418$$

(3) Includes body weight alone.

$I=a_1I_1+a_2I_2+a_3I_3$

$I_1=0.190\ x_1$

$I_2=0.005\ x_2$

$I_3=0.000\ x_3$

$=x_1$

$r_{1H}=0.398$

The x's are in terms of deviations from the means. If all lambs being indexed have the same amount of information on each of the characters studied the absolute values can be used rather than the deviations. $x_1$ and $x_2$ are measured in kilograms and $x_3$ will have a value of one for singles and two for twins. Comparison of animals by index should be done within year, season and sex. Adjustments should be made for the effect of age of dam.

*Discussion.* Any selection index should include only heritable traits with economic importance. The index provides the most efficient method of giving the right amount of emphasis to the traits considered. The resulting genetic improvement will depend on the number of traits considered, the heritability of each trait, the genetic and phenotypic correlations between traits and the intensity of selection.

Rahmani lambs are slow growers and they do not reach market weight until they are close to one year of age. Selection of ram and ewe lambs for replacements is partly done at weaning and the rest of it is done when they are 12 months old. This is the most important and intensive selection during the lifetime of the sheep. The characters thought to be of most economic importance, at that age, were body weight, fleece weight and type of birth.

The considerations previously given in estimating the economic values of each trait might be given different emphasis, depending on the location of the farm, type of farming and market prices and costs in different localities. Accurate and efficient estimates of the economic values requires several things. They are the lambing percentage, replacement rate, average age of the flock and the level beyond which a change in the character does not have further effect on income. Also required are the market price of one unit of a character and the cost of maintaining, producing and marketing the products which result from a unit change in a character. Cooperation of those concerned with sheep breeding and agricultural economists is highly recommended for solving such problems.

Data available for the present index were not extensive enough to allow a realistic estimate of the genetic covariances. When these estimates are available they should be used to improve the index.

The correlations between each of the three indexes developed and the aggregate genic value show that the first index, including body weight, fleece weight and type of birth, should provide the greatest gain. The

second index, including body weight and type of birth, is more efficient than the third index which includes body weight alone. The correlation between the index and the aggregate genic value is a measure of the genetic gain expected when the index is used compared to that expected if the genotypes of the animals were known.

The second index can be used if the fleece weights are not available. Its efficiency is close to that of the first. This is primarily due to the relatively small variability of fleece weights.

Another selection problem, although less important than that of yearling sheep, is that of ewes having one lambing record. The general practice is to add to the flock more ewes than are needed for final replacement. This is because some of them may not turn out to be good mothers and hence leave the flock. An index developed for ewes having one lambing record is as follows:

$$I = a_1 I_1 + a_2 I_2 + a_3 I_3$$
$$I_1 = .187\, x_1 + .943\, x_2 + .843\, x_3$$
$$I_2 = .000\, x_1 + .384\, x_2 - .029\, x_3$$
$$I_3 = .001\, x_1 - .003\, x_2 + .088\, x_3$$
$$= x_I + 11\, x_2 + 4\, x_3$$
$$r_{IH} = .473.$$

where $x_1$, $x_2$ and $x_3$ are the yearling body weight, yearling fleece weight and type of birth produced by ewe, respectively. The aggregate genic value is the same as that defined earlier. The phenotypic covariances of body weight and fleece weight with type of birth were 0.49 and 0.01 respectively, as obtained from the corresponding correlations given in table 3. The other variances and covariances needed were taken from tables 2 and 4.

Comparing the correlations between each index and the aggregate genic value showed that this index is more efficient than any of the three estimated for yearlings. This was expected since type of birth is a measure of the animal's own performance and not of its dam as used in the other indexes.

Culling should not be based on index alone. Defects must be selected against and other information considered important must be taken into account in particular cases. The applicability of the index for different kinds of flocks and localities will depend on the amount of data available and on the magnitude of the differences in the composition of the flock and management and feeding practices.

## Summary

In the present study three indexes for selecting yearling Rahmani sheep were developed. The traits selected for were: body weight, fleece weight and type of birth. The relative economic values, the phenotypic and genetic variances and covariances required for the indexes were obtained and discussed. The indexes are as follows:

(1) Includes body weight ($x_1$), fleece weight ($x_2$) and type of birth ($x_3$).

$I = x_1 + 13.1\ x_2 + 8.2\ x_3$

(2) Includes body weight ($x_1$) and type of birth ($x_3$).

$I = x_1 + 5.6\ x_3$

(3) Includes body weight alone.

$I = x_1$

The correlations between each index and the aggregate genic value (H) were obtained and used in comparing the indexes. The most efficient was index (1), the least, index (3).

An index for a ewe with a lambing record was also constructed. It contained body weight and fleece weight as a yearling and her own lamb production.

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# ABSTRACTS OF PAPERS FOR PRESENTATION AT THE 51ST ANNUAL NATIONAL MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

The meeting will be held November 27 and 28 in the Hotel Sherman, Chicago. The abstracts include program papers for the research sections and papers to be "read by title."

1. SOME CARBOHYDRATE METABOLISM STUDIES WITH DWARF AND NON-DWARF CATTLE. R. E. Taylor and E. J. Turman, *Oklahoma State University*.

Changes in the blood glucose levels of 65 non-dwarf and 17 dwarf cattle of the Hereford and Angus breeds were measured after the intravenous injections of epinephrine, insulin, and glucose in both fasted and non-fasted animals. Most of the animals were yearlings; however, mature cows were also used in the epinephrine studies. Both fasted and non-fasted yearling dwarfs responded to a single injection of 0.25 cc. epinephrine/100 lb. with smaller increases in blood glucose than did non-dwarf animals. Before fasting, the percent increases of the 20-minute sample over the initial sample were 69.7% for the non-dwarf, and 35.7% for the dwarf ($P<.05$). Differences between fasted yearlings were not significant. Epinephrine hyperglycemic differences between fasted pedigree clean and known carrier cows were very small. Glucose tolerance curves were similar for the dwarf and non-dwarf groups after the intravenous administration of 0.5 gm. glucose/kg. body weight. Fasting the animals for 72 hours resulted in a decreased tolerance for glucose. Dwarf animals were more sensitive than non-dwarfs to the injection of 0.36 unit insulin/lb. body weight when both were not fasted. Six hours after insulin, the blood glucose values of the dwarf (43.0 mg.%) and non-dwarf (57.4 mg.%) were significantly different ($P<.025$), and represented respective decreases of 30.3% and 3.8% from initial values ($P<.001$). A three-day fast abolished the significant differences which had existed before fasting.

2. THE EFFECT OF THE DWARF GENE ON CARBOHYDRATE METABOLISM IN BEEF CATTLE. Charles W. Foley and John F. Lasley, *University of Missouri*.

An insulin tolerance test was conducted on pedigree clean, known carriers, and dwarf beef animals. This test involved the measurement and comparison of insulin induced hypoglycemia and its duration following two successive different levels of insulin administration. An initial administration of 0.8 units was followed at 48 hours with 0.3 units per kg. of body weight. Blood sugar values were determined by the Folin-Wu and the Nelson-Somogyi methods. A significant difference ($P<.01$) existed between insulin tolerance curves for the three genotypes. Following the higher dosage, significant differences ($P<.01$) were observed for the mean sugar values between all genotypes regardless of method of sugar determination used. Following the lower insulin dosage dwarf animals differed ($P<.01$) from those phenotypically normal; however, a significant difference was not found between clean and carrier animals (Nelson-Somogyi). A difference ($P<.05$) existed between clean and carriers at the lower dosage with the Folin-Wu method. Correlations were observed between blood sugar readings taken at comparable times for the two dosages. Similar tolerance curves were obtained on clean

and dwarf cattle, but not for carriers. (Folin-Wu) This indicated that dwarf and clean animals responded comparable (within genotype) at both dosages while the carriers reacted differently at the two insulin levels. A lower "area glucose change index" derived from the up and down flucuations above and below the initial sugar reading following insulin administration indicated that the dwarf animals were the most sensitive of the genotypes studied.

3. AN EVALUATION OF THE X-RAY METHOD FOR IDENTIFYING CARRIERS OF THE SNORTER DWARF GENE IN BEEF CATTLE. B. J. Rankin, E. J. Turman, B. J. Watkins, Doyle Chambers and D. F. Stephens, *Oklahoma State University*.

In an attempt to determine the accuracy of the X-ray method for identifying the three genotypes for snorter dwarfism, lateral lumbar radiographs were made of over 1500 calves produced in several lines of Hereford and Angus Cattle. Genotype predictions were based on the degree of abnormality seen in the lumbar vertebrae. In all, 85 animals of known genotype were X-rayed, including 36 dwarf carriers and 49 dwarfs. In a Hereford herd that was presumed to be dwarf free 317 calves were X-rayed. The data obtained in this study indicate: (1) The X-ray method has an accuracy of approximately 78% in identifying dwarf carriers, approximately 74% in identifying dwarf-free animals, and approximately 96% in identifying dwarf calves. (2) The greatest number of errors in predictions are found in the range of normal to mildly abnormal vertebrae. (3) More males have abnormal vertebrae than females, and the abnormalities seem to be more extreme in the males. (5) The X-ray method is not highly accurate in identifying carriers and non-carriers of the dwarf gene, but it is highly accurate in identifying dwarf calves.

4. COMPARISON OF SOME HEMATOLOGICAL VALUES FOR BEEF CATTLE OF DIFFERENT DWARFISM GENOTYPES. L. E. Lucas and E. J. Turman, *Oklahoma State University*.

This study was conducted on 183 beef cattle of varying ages to compare the mean values of different dwarfism genotypes for several hematological measurements. These measurements included erythrocyte fragility, hemoglobin, hematocrit, erythrocyte number, specific gravity of plasma, electrophoretic analysis of the plasma proteins, and leucocyte differential counts. There were highly significant differences between age groups in percent hemolysis of erythrocytes in 0.56% saline as measured colorimetrically. Mean values for percent hemolysis by age groups were one week or less of age, 34.2%; 1 to 2 months of age, 75.5%; 7 to 8 months of age, 92.6%; 18 months of age, 84.3%; and, 3 to 9 years, 44.7%. There were highly significant differences between genotypes in the fragility of erythrocytes of calves one week or less of age. As measured in 0.56% saline, known carriers had more resistant erythrocytes (20.5% hemolysis) than did pedigree clean calves (44.7% hemolysis). There were no significant differences between genotypes in values for hemoglobin, hematocrit, erythrocyte number, specific gravity of plasma, plasma protein fractions, or leucocyte differential counts. There were highly significant increases in the mean values for hemoglobin, hematocrit, and erythrocyte number with increasing age from birth to 3 months of age. The mean values for plasma specific gravity decreased significantly from birth to 3 months of age.

5. THE INFLUENCE OF ENVIRONMENT ON CANCER EYE IN CATTLE. David E. Anderson, *The University of Texas M.D. Anderson Hospital and Tumor Institute*.

Previous reports on the hereditary aspects of cancer eye have shown the additive genetic variance to account for 17% to 41% of the total variability in susceptibility,

and differences from allelic and non-allelic interactions for less than 10%. Therefore, at least 50% of the variance is apparently due to some environmental sources of variation. Opportunity for the detection and study of one such factor was afforded by a project initiated by Oklahoma Agricultural Experiment Station to determine the effect of three levels of supplemental winter feeding on the lifetime production of beef cows. Differences in feeding affected cancer eye importantly. A high level of feeding significantly increased the average number of sites on the eyes affected by lesions (0.8 for the low level; 1.2, medium; and 1.7, high) and also their rate of increase with age (regression of 0.12 for the low; and 0.19, medium and high), increased the stage of pathogenesis of lesions, and decreased the percentage of survivors (90%, low; 70%, medium; and 60%, high). A possible explanation is that a high nutritional level hastens the aging process so that animals reach an older physiological age at a younger chronological age than on lower feeding levels.

6. THE OCCURRENCE OF ABLINISM IN REGISTERED HEREFORD BEEF CATTLE. C. C. O'Mary and M. E. Ensminger, *Washington State University*.

Three albinos were observed in a small herd of registered Hereford cattle where a young bull was mated to two of his full-sisters and four of his half-sisters. This bull (No. IV), his sire (No. II), and eight close female relatives were acquired for further breeding tests. Two of the females were old cows (full-sisters). One of these was the dam of bull No. IV. The other six females were daughters of these two cows (three from each) and by sire No. II. Three albinos were produced this year. Two of these were out of cows that had produced albinos previously, and the third was out of a cow producing her first calf. All three albinos resulted from full brother-sister matings. Light pigmented areas appear on the inside of the rear legs of the calves, but a typical "ghost pattern" of the Hereford has not appeared in any one of these three calves. In sunlight the calves show photophobia but in other respects they appear normal. Blood types have been obtained on the first two albinos born this year and on their sire and dams. The two albino calves qualify as the offspring of the indicated parents. The blood types of all five animals are very similar.

7. GENETIC PARAMETERS OF BIRTH AND 140-DAY WEIGHTS IN PUREBRED LAMBS. Roy L. Butcher, R. S. Dunbar, and J. A. Welch, *West Virginia University*.

The birth weights of 717 offspring-dam pairs and the 140-day weights of 402 offspring-dam pairs were used to calculate the heritability estimates of these two characteristics in lambs. These data were collected from 1947 through 1958 on the Station flock of purebred Corriedales, Hampshires, Southdowns, and Shropshires. Birth weights were corrected for year of birth, sex, age of dam (two years old vs. mature), and type of birth; and the 140-day weights were corrected for all of these plus the type of rearing. Heritability estimates of birth weight by the intrasire regression of offspring on dam, the intra-sire correlation between offspring and dam, and the paternal-sib correlation were Corriedales —.22, —.15, and 0.07; Hampshires —.13, —.35, and 0.12; Southdowns —.08, —.05, and 0.16; and pooled data —.14, —.17, and 0.10, respectively. An estimate for the Shropshires by the intra-sire regression was —.10. Heritability estimates of 140-day weight by the intra-sire regression of offspring on dam, the intrasire correlation between offspring and dam, and the paternal-sib correlation were Corriedales 0.03, 0.03, and —.08; Hampshire —.06, —.0°, and 0.06; Southdowns 0.08, 0.12, and 0.01; and pooled data 0.02, 0.02, and 0.00 respectively. Phenotypic correlations computed between birth weight and 140-day weight on an intra-sire basis were Corriedales 0.35, Hampshires 0.40, Southdowns 0.16, Shropshires 0.37, and pooled

data (665 lambs) 0.32. Estimates of genetic correlations calculated with only 394 offspring-dam pairs are of little value as they far exceed the normal limits of a correlation due to the large sampling error.

8. HERITABILITY OF REPRODUCTIVE PERFORMANCE IN BEEF COWS. R. L. Davenport, H. H. Stonaker, T. M. Sutherland and K. H. Riddle, *Colorado State University*.

The calving records of contemporary cows by sire groups from years 1946 through 1955 were studied. Heritability estimates of reproductive performance were calculated by the paternal half-sib method. The estimates of heritability and repeatability were developed from calving data of 3-, 4-, and 5-year-old cows. The criterion used to measure breeding efficiency was the ability of the cow to produce a live calf at birth. The calving records were classified in an all-or-none manner in either one of two mutually exclusive classes. The value of 1 was assigned to a dam producing a live calf and a zero was given to others. An estimate of the heritability of reproductive performance was found to be 0.139 and 0.150 for crosses and inbreds respectively. Repeatability of reproductive performance was calculated as 0.08 on a within year basis and 0.10 where year effect was included. Since automatic and/or purposeful culling did exist, these data are subject to some bias. The amount of selection for fertility, however, proved to be small on younger cows. The data from cows over 5 years of age were not used because of selection pressure to eliminate erratic producing and barren cows. Years, sires, ages of dam, and intensities of inbreeding, when subjected to chi-square analysis showed significant effects on live calves born ($P=.05$). Line of breeding when analyzed by chi-square approached significance in both the inbred and cross groups. A significant difference was observed in live calves born between the inbred and crosses. However, upon removal of the two-year-old cows in each group a non-significant chi-square value was found.

9. SOME FACTORS INFLUENCING VARIATION IN 28-DAY GAINS OF FEEDLOT CATTLE. T. C. Cartwright and E. E. Dayhoff, *Texas Agricultural Experiment Station*.

Weights were taken of 2420 bulls, heifers, and steers, fed on 140-day gain tests from 1952 through 1958, on two consecutive days at the beginning and at the end and once every 28 days. Years were grouped according to the weighing technique: (I) no shrink, (II) overnight feed and water shrink, and (III) overnight feed and water shrink at beginning and end only. Repeatabilities of 28-day gain, within sex and breed, for each year-group ranged from —.13 to —.03, indicating large individual variance relative to variance among animals. Repeatabilities for beginning and end weights were all above 0.98. Periodic gains tended to be cyclic or compensatory. The relatively large variance of gains of individuals appears to be caused by periodic differences in tissue gain as well as by transient day-to-day differences in fill. Variances associated with bulls were larger, but the coefficients of variability were smaller. Within animal variances were significantly lower in year group I than in II and III for gains but higher for consecutive-day weights. Among animal variances followed the same trend for gain but were not different for weights. There were some differences among Herefords, Brahmans, and the $F_1$'s between them but the trend was the same with respect to year group. Gain in each of the five 28-day periods was slightly negatively correlated (—.10 to —.02) with gain in the subsequent 28 days, but all were positively correlated (0.44 to 0.55) with total gain. The correlation of accumulated gain with total gain increased as periods progressed as follows: 0.50, 0.73, 0.84 and 0.91.

10. INHERITANCE OF CERTAIN MATERNAL TRAITS IN BEEF CATTLE. Nat M. Kieffer, Doyle Chambers and D. F. Stephens, *Oklahoma State University*.

The inheritance of maternal effects for birth weight, weaning weight, and condition score was studied by regressing the average performance of the daughters' calves on the average performance of the dams' calves and from the intraclass correlations of the average performance of calves produced by paternal half-sisters. The data were collected from four different herds. All corrections of the data were made separately for each herd using correction factors which were computed from the herds to which they were applied. The 295 daughters used in the intrasire regression of offspring on dam were by 45 different sires. The 498 paternal half-sisters in the correlation study were sired by 68 different bulls. The daughter-dam pairs were divided into subclasses by sire of the daughter and birth year of the daughter and of the dam. The intra-herd, intrasire regression of the records of contemporary daughters on the records of contemporary dams when pooled over all herds yielded heritability estimates of 0.40, 0.32, and zero for maternal effects on birth weight, weaning weight, and weaning score, respectively. The paternal half-sisters were grouped into subclasses within each herd and line of breeding according to their year of birth. All analyses were made on an intra-herd basis among contemporary females and pooled over all herds. These estimates of heritability from paternal half-sib intraclass correlations were 0.60, 0.39 and 0.04 for maternal effects on birth weight, weaning weight, and condition score, respectively.

11. COMPONENTS OF GENETIC VARIANCE IN SWINE AS ESTIMATED FROM THE REGRESSION OF PHENOTYPIC VARIANCE ON RELATIONSHIP WITHIN PENS. D. F. Cox, *Iowa State University*.

Data from the Iowa Swine Testing Station, including five seasons and involving 342 pens of three and four pigs, were studied. Daily gain from 60 to 200 lb. and backfat thickness measured by live probe at 200 lb. were studied. The relationships among the pigs within each entry were computed from their pedigrees traced back to their grandparents. Since the individuals in an entry were required to be from the same sire and out of at least three litters the relationships could vary only from half sibs, where the dams were unrelated, to full sibs in the case of litter mates. Two orthogonal contrasts were made within each set of three individuals and the resulting phenotypic variances were regressed on the genetic variances expected from the existing relationships. Estimating separately the components of epistatic and maternal variance seemed possible theoretically but was found impractical because the restricted range of the relationships and the number of comparisons involved made the sampling errors inordinately large. The joint estimate of additive and dominance variance was 0.0111 for gain in pounds per day and 0.0400 for probe in inches of backfat. Heritability derived from these estimates was 0.33 for gain and was more than 1.00 for probe because the estimate of the environmental component was negative. Genetic and environmental components of covariance were estimated by similar methods.

12. EVALUATION OF FINAL WEIGHT IN THE SELECTION OF PERFORMANCE TESTED BULLS. Delwyn Dearborn and C. A. Dinkel, *South Dakota State College*.

Seven years' data on 224 bull calves representing 21 sires were analyzed to determine the effectiveness of using final weight as a criterion in the selection of performance tested bulls. The data were corrected for age and analyzed by the method of least squares with constants fitted for sires, years, ranches, and inbreeding classes. The final weights studied were those obtained after 140, 168, and 196 days on performance test, and the average age for each period was 12, 13, and 14 months respectively. A comparison of effect of length of feeding period on selection for final weight was

available. Sire differences for 140-, 168-, and 196-day final weight were all highly significant. The paternal half-sib heritability estimates for 140-, 168-, and 196-day final weight were 0.41, 0.44, and 0.44, respectively. The standard errors of these estimates are 0.18, 0.19, and 0.19, respectively. The heritability estimates for daily gain for the three feeding periods were 0.39, 0.45, and 0.43, respectively. The comparison of length of feeding period is based on comparing the products derived by multiplying the heritability estimate times the appropriate intra-ranch, intra-year standard deviation. The results indicated that selection for final weight would be 89% as effective in the 140-day period as it would be in the 168-day period and 85% as effective as the 196-day period. The selection for final weight in the 168-day period would be 95% as effective as the 196-day period. A genetic correlation of 0.81 between 196-day final weight and 196-day rate of gain was found. This analysis indicates that selection for either final weight or rate of gain should give comparable results.

13. COMPARISON OF THREE SYSTEMS OF PERFORMANCE TESTING BEEF CATTLE. C. C. O'Mary, Donald W. Vance and M. E. Ensminger, *Washington State University.*

Fifteen bulls and twenty-three heifers were placed on experiment to compare three systems of performance testing. All of the bulls and seven of the heifers were individually fed an all-pelleted ration. The remainder of the heifers were group fed, eight to a group. The systems of performance testing compared were (1) a time-constant test of 150 days with all animals starting and finishing at the same time; (2) a weight-constant test in which the bulls were tested from 500 to 800 lb. and heifers from 500 to 750 lb.; and (3) an age-constant test of 150 days duration beginning when the animals reached 243 days of age. At the beginning of the time-constant test the bulls ranged in ages from 168 days to 229 days. Their weights ranged from 334 lb. to 568 lb. The heifers ranged in ages from 163 days to 243 days and in weights from 250 lb. to 508 lb. Analyses of variance showed no significant difference between the three tests on rate of gain for either bulls or heifers. Correlation coefficients of average daily gain with feed efficiency for the bulls on the three management systems were as follows: (1) time-constant —.21; (2) weight-constant —.38; and (3) age-constant —.58. The correlation coefficient obtained on the age-constant test differed significantly from those obtained on the other two tests. Correlation coefficients of average daily gain and feed efficiency for the heifers were —.75; —.62; and —.68, respectively, for the three systems. These did not differ significantly.

14. GENERAL AND SPECIFIC COMBINING ABILITIES IN CROSSES AMONG SIX INBRED LINES OF SWINE. H. O. Hetzer, R. E. Comstock, J. H. Zeller, R. L. Hiner and W. R. Harvey, *Swine Research Branch, U.S.D.A. and University of Minnesota.*

Estimates of the material g.c.a. and s.c.a. effects of six inbred lines developed at Beltsville, Md. were obtained from data on 218 single cross litters farrowed in 1947, 1948 and 1950. The traits studied were litter size, litter weight and pig weight at birth, 21 and 56 days, pig weight at 98 and 140 days, daily gain from 56 days to 225 pounds, dressing percentage, yield of 4 lean cuts, yield of bacon, sum of 5 preferred cuts, yield of fat cuts and backfat thickness. Maternal effects were not significant for litter size but they differed significantly for litter and pig weight at 56 days, pig weight at 140 days, daily gain, dressing percentage, yield of bacon, and yield of fat cuts, accounting for 7 to 21% of the variation in the latter five characteristics. Differences in g.c.a. were significant for one pre-weaning trait, litter weight at 56 days. However they were significant for all post-weaning growth traits and for all carcass traits except dressing percentage, accounting for 5 to 7 and 6 to 16% of the variation in these two sets of traits. S.c.a. effects were significant only for yield of bacon, indicating that dominance

and epistasis contributed little if anything to the variation in these data. Correlation analyses suggested rather strongly that the inbreeding practiced in developing the lines affected adversely maternal abilities for litter size, growth rate and yield of lean cuts while it had the opposite effect on the lines' g.c.a. for these traits.

15. THE COMBINING ABILITIES OF THIRTEEN INBRED LINES OF HEREFORD CATTLE. G. V. O'Bleness, H. H. Stonaker, and C. R. Henderson, *Colorado State University and Cornell University.*

The weaning weights of 594 single cross animals were used to evaluate the performance of 13 inbred lines when crossed with each other and when crossed with an outbred control group. The outbred controls were included as a 14th line in the analysis. In this study the weaning weights were corrected for sex, age of dam and inbreeding of dam before setting up the least squares equations. Year of birth was included in the least squares equations. The differences between lines of sire and between lines of dams were significant at the 0.01 level. The least squares estimates were used to rank the lines when the lines were used as sires and as dams. The order of the lines was not necessarily the same in the two rankings as indicated by a rank correlation of 0.11.

16. THE NUMBER OF DAUGHTER-DAM PAIRS NEEDED FOR ESTIMATING HERITABILITY. L. D. Van Vleck, S. R. Searle, and C. R. Henderson, *Cornell University.*

One method of estimating heritability is from the regression of daughter records on dam records. In the one-way classification analysis (where the classes are usually herds or sires) the expression for the variance of the heritability estimate can be rearranged as:

$$N = \left(\frac{R}{R-1}\right)\left(\frac{4X - H^2 + V(H)}{V(H)}\right)$$

where N is the number of daughter-dam pairs, R is the average number of pairs per class, X is the ratio of the intraclass variances of the daughter records to the dam records, H is the heritability estimate, and V(H) is the variance of the estimate. Tables of N have been computed for various combinations of these variables. They can be used to indicate, for an anticipated value of H, the number of daughter-dam pairs required in order to estimate H with a pre-determined standard error, for given values of X and R. In practice X usually approximates to 1.00, and as R increases from 2 to 8 the values of N decrease rapidly for all values of H and V(H). For $V(H) = (0.04)^2$ the number of pairs required when $H = 1$ is approximately 75% of the number needed when $H = 0$, for all values of R; the number of pairs needed when $R = 20$ is approximately half those needed when $R = 2$, for any value of H. Doubling the desired confidence interval from $\pm 0.08$ to $\pm 0.16$ reduces the number of pairs required by a factor of 4.

17. INVITATIONAL PAPER—THE PROBLEM OF GENETIC CONTROL. E. L. Lasley, *Miner Research Institute.*

18. EFFECT OF CROSSBREEDING ON BODY MEASUREMENTS OF DUAL PURPOSE CALVES. L. M. Scott and T. G. Martin, *Purdue University and Dairy Cattle Research Branch, ARS.*

Three breeds of cattle (Red Poll, Milking Shorthorn, and Red Dane) were mated to produce all possible types of crossbred and pure bred progeny. Body weight and five linear body measurements were recorded on 128 three-month-old and 137 six-month-old

animals. These data were analyzed by the method of least squares to provide unbiased estimates of the effects of crossbreeding, sex, breed of dam, breed of sire, sire in breed, and several interactions. Environmental trends were minimized by analyzing a portion of the data (85 three-month-old and 89 six-month-old animals) which, from visual inspection, appeared to be relatively free of environmental effects. At three months of age, crossbreds were larger than purebreds in body weight, wither height, and chest depth and purebreds were longer in length withers to pins than crossbreds. At six months of age, crossbreds were found to be larger in all measurements than purebreds. Effects of crossbreeding as measured by the dam x sire interaction were found to be significant in the analysis of the complete set of data for the following measurements: Three-month heart girth (purebreds larger), six-month weight, wither height, and length withers to hips (crossbreds larger). In the second analysis, the observations were too few to show significant differences. It was concluded that the effects of crossbreeding were generally small, but the crossbreds were larger. Generally, the effects of sex, breed of sire, and breed of dam were not significant.

19. EXPRESSION OF HYBRID VIGOR IN BIRTH WEIGHTS OF BEEF CALVES. W. L. Reynolds, M. Koger, W. G. Kirk and F. M. Peacock, *University of Florida.*

A study was made of the birth weights of 940 calves of Brahman breeding and crosses involving Brahman, Shorthorn, Angus, Hereford, Native and Santa Gertrudis. Birth weights were adjusted by the method of fitting constants for the influence of year, sex, lactation status of dam, month of birth, pasture, age of dam, and breed. The general mean was 63.1 lb. with a 3.7 lb. advantage of male calves over females. Calves born to 2-, 3-, and 4-year-old dams were 5.5, 3.9, and 2.2 lb. lighter than calves of cows 5 to 10 years of age. Purebred Brahman calves or $F_1$ Shorthorn $\times$ Brahman calves were comparable in weight and were 2.1 lb. and 2.4 lb. lighter than the mean weight of all calves. Calves of ½, ⅝, ¾, and ⅞ Brahman breeding sired by Brahman bulls deviated from the general mean by +3.2, +2.1, +1.9 and −3.9 lb. respectively. Calves sired by crossbred Shorthorn $\times$ Brahman bulls were 1.8 lb. lighter at birth than the mean weight of all calves whereas calves from Hereford, Angus, Shorthorn, and Santa Gertrudis bulls were 2.2 lb. heavier than the mean weight. From these data it would appear that maternal factors influenced birth weight to a greater extent than hybrid vigor. Certain groups of calves exhibiting no advantage in birth weight showed unmistakable hybrid vigor at weaning. This behavior may be related to differences in gestation length which was not measured in this study.

20. BIRTH WEIGHTS AND WEANING WEIGHTS OF CROSSBRED LAMBS. W. E. Rempel, R. E. Comstock, D. Reimer, A. B. Salmela and Harley Hanke, *University of Minnesota.*

Single cross performance of lambs from Minnesota lines of ewes were compared. Birth weights of 790 lambs and 100-day weights of 707 lambs were analyzed. A least-squares technic was used to obtain effects for station and breed of ewe, breed of ram, single versus multiple birth, and male versus female. An effect for being born twin and raised single was also estimated for 100-day weights. Station and breed of ewe effects are unfounded. The b-values for station and breed of ewe effects are Minn. 106, 9.75; Minn. 105, 9.31; Minn. 103, 9.21; Minn. 107, 8.49; and, Minn. 100, 7.80 lb. Breed of ram effects are Minn 106, 1.61; Suffolk, 1.08; Minn. 102, 0.86; Hampshire, 0.56; Minn. 105, 0.49; Minn. 107, 0.24; and, Minn. 100, zero lb. The advantage of being born single rather than twin was 1.62 lb., and of being male rather than female was 0.55 lb. The station and female effects for 100-day weights were Minn. 106, 72.47; Minn. 100, 65.84; Minn. 105, 65.32; Minn. 103, 63.46; and, Minn. 107, 46.20 lb. The breed of male effects were Suffolk, 5.34; Hampshire, 3.26; Minn. 106, 2.92; Minn. 107, 0.45;

Minn. 102, 0.15; Minn. 100, zero; Minn. 105, —.10; and, Minn. 103, —.93 lb. The advantage of being single rather than twin was 8.61 lb. There was a 2.45-lb. advantage for a twin raised as a single rather than a twin and 3.52-lb. advantage in being male rather than female.

21. HERITABILITY OF GROWTH IN A LINE OF SWINE DEVELOPED FROM A CROSSBRED FOUNDATION. W. E. Rempel and H. F. El-Issawi, *University of Minnesota.*

The Minnesota No. 3 breed of swine originated from a crossbred foundation in which the multiple-sire system of mating was used for the first five years. About 10 boars were used each generation to sire from 50 to 60 litters. A generation interval of 1 year has been maintained. Inbreeding has been mild and segregation for superficial traits indicates that considerable genetic variability is present. Growth rate was chosen to check a possible difference in magnitude of heritability in this population and other estimates. Estimates of heritability for growth rate were obtained from the regression of offspring on dam. Six years of data at the Rosemount station involving 304 litters yielded a regression of 0.1111±.0523 or a heritability of 22%. Three years data at the Morris station involving 85 litters yielded a regression of 0.1721±.0980 or a heritability of 34%. In 1958, sires were used for individual mating so that intra-sire estimates of regression of offspring on dam could be obtained. Thirty-six litters from 13 sires at Rosemount and 22 litters from 10 sires at Morris were used to obtain the regression coefficients. The two estimates were —.1356±.1868 and 0.1621±.3008, respectively. The small numbers used in these latter estimates renders them relatively unreliable owing to sampling error as indicated by the standard errors. Estimates of heritability for growth rate obtained in this study fall within the range of those reported in the literature.

22. INTERRELATIONSHIPS BETWEEN WEIGHTS AT DIFFERENT AGES OF YORKSHIRE, LANDRACE, AND YORKSHIRE-LANDRACE CROSSBRED PIGS. M. A. MacDonald, J. E. Moxley and L. H. Hamilton, *Macdonald College (McGill University), Quebec, Canada.*

Selection of potential breeding stock early in life is essential if reproductive efficiency is to be realized. Differences in allometric growth and liveweight gain in purebred Yorkshire, Landrace-Yorkshire crossbreds and backcrosses employing these two breeds led to the hypothesis that relationships between weights at different ages differ according to breeding plan. Interrelationships between birthweight, 21-day, 56-day and 154-day weights for 351 pigs within breeding groups raised at Macdonald College during 1957 and 1958 were analyzed. Gross correlations based on individual weights indicated a positive but relatively low association of weights at early ages with weights at later ages, and within litter correlations indicated a low predictability of weight at a given age on future gains by pigs. For purebred Yorkshires, the 56-day weight was the best indication of weight at 154 days of age. For Landrace-Yorkshire crossbreds, birthweight was the best indication of 154-day weight; but there was little difference between birthweight correlations and those involving 56-day weight with 154-day weights. For Landrace-Yorkshire x Yorkshire or Landrace-Yorkshire x Landrace backcross pigs, the best indication of weight at 154 days was weaning weight (21 days). A birthweight of 1 lb. above average resulted in a positive increase above average of 3.4, 3.9 and 3.2 lb. at 21 days; 6.4, 9.0 and 6.0 lb. at 56 days and 18.4, 28.8 and 14.0 lb. at 154 days for purebred, crossbred and backcross pigs, respectively. Survival rates were significantly higher for pigs with heavy birthweights. It may be concluded maximum selection potential is not realized by selecting breeding animals from all the groups studied at a constant age.

23. SOME FACTORS INFLUENCING PHYSICAL COMPONENTS OF SWINE CARCASSES. L. J. Sumption, R. G. DeBower, C. W. Kasson and C. H. Adams, *University of Nebraska.*

To effect future favorable quantitative changes in physical composition of carcasses it is necessary to re-evaluate some aspects of existing methodology and obtain additional basic knowledge of growth and development to augment more precise approaches to evaluation and selection. In the process of appraising foundation material for a long term selection study, data were collected from 151 carcasses among which the following breeding groups were represented: Hampshire, Yorkshire, Minnesota No. 1, Hamp x York, Hamp x Minn. No. 1, York x Minn. No. 1, Duroc x Hamp, Minn. No. 1 x Duroc, and York x Duroc. Data included cold weight, backfat thickness, length, % lean cuts, estimated total carcass lean and fat %, loin eye areas at four points, and the weight of the longissimus dorsi in the loin cut of each carcass. Loin muscle samples were collected for histological studies. An initial summary of data reveals substantial differences in breeding groups for the following factors: Backfat thickness, % lean cuts (LC), loin eye area (LA), loin eye weight (LW) and length (LE). There is an indication of heterosis effects for loin eye area and loin eye weight. The following simple correlations are reported at this time: LC x LA=.49, LC x LW=.63, LA x LW=.70, LE x LA=.06, LE x LW=.48. Partial correlations with cold weight (CW) held constant were LA x LW·CW=.65, LE x LA·CW=−.10, LE x LW·CW=.34. The superiority of using a three dimensional measurement of muscle mass is clearly suggested. The relationship between length and loin eye weight does not support the "rubber band" theory but that a smaller area can be compensated for in a longer pig.

24. THERMISTER THERMOMETER FOR ESTIMATING FAT THICKNESS ON LIVE BEEF CATTLE. R. B. Warren, V. H. Arthaud, C. H. Adams and R. M. Koch, *University of Nebraska.*

*In vivo* tissue temperatures of steers grading from prime to standard were recorded through the use of a hypodermic thermistor probe attached to a thermistor recorder. Steers were probed dorsal to the L. dorsi directly over 13th rib or over the transverse process of the 2nd lumbar vertebra. Three tissue needle probes were made approximately 3 to 4 cm. apart from a midpoint between the loin midline and the edge of the loin. The *in vivo* fat probe thickness determinations were made by measuring the depth of the needle insertion when the change in temperature from fat to lean was reflected on the thermistor thermometer. An adjustment for a hide thickness of 0.8 cm. was made. Live probe and carcass fat thickness over the loin on 12 long-fed, highly-finished heavy steers was correlated at 0.75. Forty-nine steers probed on a warm day showed a correlation of 0.47 between the probe fat and carcass fat thickness. Since 20 of the latter 49 steers were probed in the morning before the air temperature reached 85° F. and the difference between the fat and lean temperatures was greater in this period (average difference 4.2°F.-P=0.01), these data were analyzed separately. Loin probe fat and loin carcass fat thicknesses were correlated at 0.84 on these 20 steers. When the air temperature was between 65° F. and 85° F. the average tissue temperatures were: Fat—97.2±1.7° F. and 98.3±0.9° F., lean—101.9±1.2° F. and 102.5±0.7° F., rectal—102.2±1.1° F. and 104.7±0.6° F. on 28 and 49 steers, respectively. When the air temperature was between 85° F. and 95° F. the tissue temperatures of the 29 steers were: Fat—100.3±1.4° F., lean—104.1±1.1° F., rectal—105.9±0.9° F.

25. CARCASS CHARACTERISTICS OF COMPREST AND CONVENTIONAL TYPE HEREFORDS. Philip E. Skinner, R. L. Henrickson, Doyle Chambers and D. F. Stephens, *Oklahoma State University.*

Twenty-four Hereford calves dropped in a herd of Comprest breeding at Fort Reno in 1957 were visually classified at three months of age into comprest and non-

comprest types. These calves were assigned to three different groups of eight head each. The three groups were to be slaughtered at 6, 12 and 24 months of age. Each group contained four steers and four heifers, two of each sex being comprest in type. One animal of each sex and type in all groups was on a high level and one was on a low level of nutrition. Detailed carcass data were obtained from each group by standardized techniques. Analyses of variance of the pooled data were used to determine the significance of differences observed for the effects of age, type, sex, and level of nutrition. The non-comprest animals were 9% heavier at slaughter, 11% heavier in the carcass, and were longer and deeper in the carcass than their comprest mates. The non-comprest cattle were 6% larger in loin eye area. There were no significant differences between the two types in wholesale cut percentages or in the percentage of lean, fat or bone in the 9–10–11 rib. The comprest cattle graded about one-third of a grade higher than the non-comprest type. There was no difference in the shear force values obtained from broiled rib steaks from the two types. The differences in slaughter weights between the two types were greater for those on the high level of nutrition than for those on the low level.

26. AN ANALYSIS OF DIFFERENCES IN WEIGHT OF BEEF CALVES AT 60, 120, 180 AND 240 DAYS OF AGE. C. J. Brown and Elmer Krehbiel, *University of Arkansas.*

From weights taken each month, calf weights were adjusted to 60, 120, 180 and 240 days of age according to the average daily gain of each calf. Cattle maintained in two herds were studied. Data used were from 287 calves born during a 7-year period ending in 1958 in the Hereford herd and from 271 calves born during a 9-year period ending in 1958 in the Aberdeen Angus herd. Least squares estimates of the influence of year and season of birth, sex and sire of calf, and age of dam were computed at the 60-day intervals in each herd. Analysis of variance leading to variance components and percentage of variance associated with these factors were also computed at the 60-day intervals in each herd. Consistent patterns in the percentage of variance associated with the above factors at the four ages studied were noted within herds. The pattern of change however was different in the two herds. Using the least squares estimates of the above factors the weight of each calf was adjusted to a common basis and repeatability estimates calculated. At 60, 120, 180, and 240 days of age the repeatability estimate for weight of calf was 27, 28, 29, and 42%, respectively, for the Hereford calves, and 14, 16, 24, and 65%, respectively, for the Aberdeen Angus.

27. RELATIONSHIP OF INHERENT GROWTH CAPACITY OF BEEF CATTLE TO RESPONSE TO EXOGENOUS STIMULI. I. RESPONSE TO IMPLANTED STILBESTROL. D. C. England, *Oregon State College.*

Three groups of 36 weaner steers per group were fed in feedlot for 180 days on identical rations. Group 1 received no stilbestrol; group 2 received no stilbestrol during the first 90 days, but was implanted with 30 mg. stilbestrol on the 91st day; group 3 was implanted with 30 mg. stilbestrol on the 1st day and reimplanted with 15 mg. on the 91st day. Weights were taken on the 1st, 37th, 91st and 180th days. The first 37 days were considered as a period of adjustment to feedlot conditions. Correlation coefficients of total gain per animal from 37 to 91 days with total gain per animal from 91 to 180 days were calculated. For groups 1, 2 and 3 the correlation coefficients were 0.342, 0.625, and 0.294, respectively. Corresponding regression coefficients were 0.434, 0.752, and 0.382. No two of the correlation coefficients were significantly different from each other at the 5% level. The same was true of the regression coefficients. In both cases, differences were significant at $P=0.10$. Although these data lack statistical significance at generally accepted levels, the direction and relative magnitude of the correlation coefficients and regression coefficients are in harmony with the hypothesis

that inherently fast gaining animals show a greater growth response to the stimulus of implanted stilbestrol than do animals of lower inherent growth capacity. The data clearly fail to provide evidence that inherently slow gaining animals respond more favorably than inherently faster gaining animals to implanted stilbestrol.

28. CORRELATION OF COW MEASUREMENTS TO 180-DAY ADJUSTED WEANING WEIGHTS OF THEIR CALVES. C. C. O'Mary, Thomas L. Brown and M. E. Ensminger, *Washington State University.*

Fifteen body measurements were made on 20 Angus cows to determine simple correlation coefficients between each of these measurements and the 180-day adjusted weaning weights of the calves. These correlation coefficients were all positive and were as follows: foreshank length, 0.46; forearm circumference, 0.48; rump length, 0.46; foreshank circumference, 0.29; foreleg length, 0.23; height at top of shoulder, 0.25; heart girth, 0.17; point of shoulder to hook, 0.15; point of shoulder to pins, 0.33; width at hooks, 0.31; width at pins, 0.16; chest depth, 0.27; hooks to stifle, 0.00; coupling, 0.39; and skin thickness, 0.21. Only the first three cow measurements were significantly correlated with adjusted weaning weights of calves. The multiple correlation coefficient of the three measurements with weaning weights was 0.91. Forty-eight cows ranging in weight from 898 lb. to 1445 lb. were available for studying cow and calf weight relationship. A significant correlation coefficient of 0.51 was found between cow weights and the adjusted weaning weights of their calves.

29. CORRELATION OF CALIPER AND PHOTOGRAPHIC MEASUREMENTS OF CATTLE. J. R. Crockett, Marvin Koger and H. L. Chapman, Jr., *Florida Agricultural Experiment Station.*

Forty-three yearling heifers of Angus, Brahman, Devon, Brahman x Angus and Brahman x Devon breeding were measured with calipers, photographed behind a grid and weighed. Seven caliper measurements were taken in duplicate for height, depth and width from each animal. Heart girth and length of body were measured with a cloth tape. Correlation coefficients calculated from caliper and photographic measurements were 0.84 for height at withers, 0.80 for height at chest floor, 0.79 for height at hooks, and 0.36 for depth of body. Correlation coefficients calculated from photographic measurements and weight were 0.44 for height at withers, —.007 for height at chest floor, 0.58 for depth of body, and 0.28 for height at hooks. Measurements of the animals standing in a normal manner were more easily obtained from the photographs than from the caliper method.

30. MORTALITY IN SUCKLING LAMBS: CAUSES AND AGES OF OCCURRENCE. J. L. Perkins, J. G. Mattern, Jr., G. V. Hardman and J. A. Welch, *West Virginia University.*

Deaths in lambs before weaning (including stillbirths) result in considerable economic loss to the sheepman. Information concerning age and cause of death in lambs could be of value in developing practices aimed at reducing lamb mortality. Lamb deaths during the interval from birth until weaning in the Station purebred flocks were classified by age and cause of death. Flock records on 1217 lambs covering a 12-year period from 1947 through 1958 were used as the source of information for this study. The average percent lamb mortality for the entire period was 22.59. Based on all years of the 12-year period, percentages of lambs dying in the following age categories were 0–3 days of age (including stillbirths), 66.18; 4–10 days of age, 13.09; 11–30 days of age, 7.64; and 31 days of age until weaning, 13.09. A total of 79.27% of all lamb deaths occurred between birth and 10 days of age. The major causes of lamb deaths were tabulated and ranked by magnitude. Based on the entire 12-year period, the per-

centages of total mortality due to the following major causes of death were undetermined causes, 30.55; stillborn, 30.18; accidental, 10.18; failure to own or insufficient milk, 8.00; lamb diseases, 6.91; killed by dogs, 6.55; ewe abnormalities, 6.18; miscellaneous, 1.09 and frozen, 0.36.

31. A NEW PROCEDURE FOR THE HEMOLYTIC TEST USED IN CATTLE BLOOD TYPING. W. H. Stone, Janis Beckstrom, Adolf Tolle and M. R. Irwin, *The University of Wisconsin.*

The standard procedure for the hemolytic test involves three pipetting operations: Two drops of reagent (typing fluid) followed by one drop of a 2.5% suspension of red blood cells; after 15 minutes, one drop of complement (unheated rabbit normal serum) is added. In this technique false negative reactions would result if the drop of complement did not get into the tube as a result of error. The new procedure eliminates this source of error. Two drops of reagent are added as in the standard procedure. To the reagent are added two drops of a *mixture* of cells and complement prepared by combining equal volumes of a 2.5% suspension of the cell sample and complement (diluted ½ with saline). The mixture is incubated at room temperature for about 15 minutes before it is added to the reagent. Using this technique we have tested over 300 samples of cells with more than 80 different reagents and obtained clear-cut results paralleling those obtained by the standard procedure. This new procedure provides a system whereby the presence of complement can be ascertained by noting the red color of the cells in the tubes. It has the added advantage of reducing the number of pipetting operations from three to two.

32. TOTAL LAMB PRODUCTION AS AFFECTED BY EARLY WEANING. R. M. Jordan, H. E. Hanke, and D. Reimer, *University of Minnesota.*

The efficiency of lamb production may be increased by the early weaning and grain feeding of lambs. This system will increase the use of high quality commercial feeds for lamb feeding, increase the percentage of fat lambs marketed in early summer, reduce internal parasites, and may increase sheep numbers on high cost tillable land. Data were gathered on 549 lambs at three Minnesota Experiment Stations to determine (1) the effect of early weaning on subsequent gains and feed consumption, (2) the optimum age to wean lambs, and (3) methods of feeding and management of early weaned lambs. Lambs were weaned at ages ranging from 8 to 20 weeks. After weaning, lambs were grain-fed in drylot, grain-fed on pasture, or pastured without grain. Non-weaned lambs creep-fed on pasture served as controls. Results indicate that (1) lambs may be weaned at 10 to 14 weeks of age without reducing subsequent gains, (2) weaning at 8 to 10 weeks of age appears to be less satisfactory than 12 weeks, (3) early-weaned lambs should be grain-fed, either in dry-lot or on good quality pasture, (4) grain-feeding in drylot may be no more expensive than grain-feeding on pasture, and (5) grain consumption on pasture may be as great, or greater, than grain consumption in drylot. The latter depends largely on the quality of the pasture. Where low quality pasture and parasites are a problem, weaning as early as 8 weeks of age and grain feeding in drylot or on high quality pasture will result in greater lamb productivity.

33. APPETITE, GROWTH RATE AND FEED UTILIZATION IN BRAHMAN, SHORTHORN AND CROSSBRED CALVES. D. D. Hargrove, M. Koger, W. G. Kirk, F. M. Peacock, A. C. Warnick and T. J. Cunha, *University of Florida.*

Twenty-four calves of Shorthorn, Brahman and Brahman x Shorthorn breeding were weaned at 2 to 4 months of age, placed on a preliminary feeding period for 18 days and started on experiment beginning May 30. Equal numbers of steers and heifers

of each of the breed groups were used. One-half of the calves of each breed group and sex were full-fed concentrates twice daily, while the concentrate intake of the other one-half was equalized at 2% of their body weight. Hay was fed at the rate of 1 lb. per animal per day. Calves were individually fed and were weighed at weekly intervals. Feed allottment was adjusted after each weigh period. Appetite, as measured by feed intake of full-fed animals was the highest in crossbred calves, followed by Shorthorn and Brahman. At the end of 70 days on experiment, average daily gain and feed per lb. gain on equalized feed intake were respectively, 1.08 and 5.46 for Shorthorn, 1.35 and 4.77 for Brahman, and 1.22 and 4.94 for crossbreds. For full-fed calves, corresponding values were 1.27 and 5.53, 1.54 and 4.78, and 1.99 and 4.78, respectively. Breed differences were significant for average daily gain and feed efficiency. Feeding program was significant for average daily gain. The above reported results were obtained in late spring and early summer and the trial will be extended to include other seasons of the year before conclusions are drawn.

34. LIBIDO AND SPERM OUTPUT OF DAIRY BULLS EJACULATED WEEKLY AFTER RESTRAINT OR AFTER THREE FALSE MOUNTS. H. D. Hafs and R. C. Knisely, *Michigan State University.*

Twenty-eight mature dairy bulls were selected to be ejaculated once-a-week for 10 weeks to study two methods of sexual stimulation. Fourteen of the bulls were randomly chosen to be ejaculated after 10 minutes of active teasing including three false mounts and the remaining 14 were ejaculated after 10 minutes of active teasing but restrained from false mounting. The averages for ejaculate volume, percent motile sperm, sperm concentration per milliliter, total sperm per ejaculate, and motile sperm per ejaculate for the false mount bulls were 9.4 ml., 73%, 2.07 x $10^9$, 19.6 x $10^9$, and 14.3 x $10^9$, respectively, and for the restraint bulls were 8.1 ml., 72%, 2.04 x $10^9$, 16.2 x $10^9$, and 11.6 x $10^9$, respectively. The difference in sperm output was significant at the 10% level of probability. The two groups of bulls did not differ appreciably with regard to a vigor of thrust rating at ejaculation, the number of teaser animals used, or the number of locations used for teasing, but the time interval from the end of teasing to ejaculation of 14 sec. for the false mount bulls was significantly less than the 59 sec. for the restraint bulls ($P<.05$). The correlation between vigor of thrust at ejaculation and total sperm per ejaculate was 0.14 ($P<.05$). The results of this experiment indicate that bulls ejaculated after 10 minutes of active teasing with three false mounts yield about 20% more sperm than those ejaculated after comparable sexual stimulation without false mounts and that neither teasing method seriously impairs libido.

35. THE FORMOL AND KJELDAHL METHODS OF MEASURING PROTEIN IN MILK AS BASES FOR SELECTING COWS. D. O. Everson, A. E. Freeman and A. M. Meek, *Iowa State University.*

Composited individual night-and-morning milk samples from 48 Holstein cows were taken on 11 days at 28-day intervals. No sample was discarded unless the milk was non-marketable. In all, 373 samples covering all stages of lactation were analyzed. A modification of Richardson's formol titration was compared to the micro-Kjeldahl method for determining total nitrogen. The overall mean Kjeldahl determination was 3.06% protein, while that for the formol titration was 3.03% when using Richardson's factor of 1.83 for 10 ml. samples. The product—moment correlation between the two methods was 0.83 on individual samples and 0.94 when the cow's average was the unit. The excess of the Kjeldahl figure over the formol one in the individual analyses did not differ significantly from cow to cow. Neither did the sign test show any significant difference between the two methods in ranking the cows. Consequently the difference, if any, between the two methods does not seem to depend on the cow.

36. FEED LOT PERFORMANCE AND CARCASS CHARACTERISTICS OF STEERS OF VARIOUS BREEDS AND CROSSBREEDS. J. R. Crockett, Marvin Koger, H. L. Chapman, Jr. and A. Z. Palmer, *Florida Agricultural Experiment Station.*

Data from two different feeding trials at the Everglades Station were combined. Trial I (1957) included steers of grade Angus, Brahman x Hereford, Charollaise x Braham, and Santa Gertrudis breeding, with 16 steers in each breed group. Trial II (1958) included 24 steers of each of the same four breed groups as in Trial I. Experimental treatments were different for the two trials. The Angus breed indicated superior performance in nearly all characteristics except transit shrink and rib-eye area. There were no significant differences among breed groups for average daily gain in either trial. Steers of Santa Gertrudis breeding showed the least desirable carcass characteristics but were slightly superior in average daily gain. Brahman x Hereford made the slowest gains in the feed lot. Carcass grades showed significant differences with the breed groups ranked in the following order: Angus, Brahman x Hereford, Charollaise x Braham, and Santa Gertrudis. Tenderness evaluations taken from broiled loin steaks indicated no significant differences among breed groups. The Angus steers had the highest dressing percent (60.2) and the Santa Gertrudis steers (59.03) the lowest, the differences being non-significant.

37. SPERM COUNTS IN BOAR SEMEN AFTER LOCAL X-RAY EXPOSURE. R. L. Willham, D. F. Cox, M. A. Emmerson, *Iowa State University.*

Twelve boars each from the Duroc and Hampshire breeds were given single local X-ray exposures at levels of 0, 300, 600 or 900 roentgens. Four boars from the same breed, one at each treatment level, were irradiated on the same day. A General Electric Maximar unit operating at 250 KvP, 15 Ma. was used. The radiation was directed locally to the scrotum of the boar, the target distance to the center of the testicles being 35 cm. The dose-rate was 100 r per minute and the half value layer for copper was 1.3 mm. Semen collections following treatment were made at approximately weekly intervals in two sets of boars and at bi-weekly intervals in the remaining four sets. The sperm concentration of the treated boars declined sharply about 3 or 4 weeks after treatment. From about 7 to 10 weeks post-irradiation the treated boars averaged about 25,000 sperm per c.c., compared with around 500,000 sperm per c.c. for the controls. In several of the treated boars, especially those receiving high levels of radiation, sperm were completely absent. Sperm concentrations began to increase slowly in the irradiated boars about 11 or 12 weeks following treatment. Sperm concentration seemed to be depressed more and for a longer period at the higher dosages of radiation.

38. GROWTH RATE, CARCASS GRADE AND NET RETURNS OF SUFFOLK- AND SOUTHDOWN-SIRED LAMBS OUT OF RANGE EWES. G. E. Bradford, W. C. Weir and D. T. Torell, *University of California.*

A three-year experiment was conducted at the Hopland Field Station to compare the performance of Southdown- and Suffolk-sired lambs in an area characterized by a relatively short period of good feed supply. One hundred Whiteface ewes of mixed breeding were allotted each year to three rams of each breed, the following data being recorded on the lambs: Birth weight, weaning weight, weaning grade ("fat" or "feeder"), gains of feeder lambs during a 60-day period on irrigated pasture, carcass weight, Federal carcass grade, and price per pound for both fat and feeder groups. The three-year average results, for Suffolk- and Southdown-sired groups respectively, were as follows: Lambs weaned per ewe alive at lambing, 0.85 and 0.91; 120-day lamb weight, 71.3 and 59.3 lb.; percentage "fats" at weaning, 24 and 30; daily gain on irrigated pasture, 0.31 and 0.23 lb.; dressing percent (based on unshrunk live weights), 48.3 and 49.1; percent of carcasses grading prime, choice, good and utility, 0, 59, 38,

3 and 7, 73, 18 and 2; carcass price per pound (gross), $0.40 and $0.41; carcass price per pound (net after killing charges deducted), $0.36 and $0.36; returns per ewe alive at lambing, $13.15 and $11.38. The results indicate that the lighter weights of the Southdown-sired lambs were not compensated for by their slightly higher carcass grades and percentage survival to weaning, and that the lambs sired by rams of the larger breed returned approximately 16% more lamb income per ewe.

39. BEEF CATTLE IMPROVEMENT THROUGH PACKER-RANCHER COOPERATION. H. J. Hill, W. W. Smutz, Jr. and V. R. VanDervoort, *Beef Cattle Improvement Research.*

Armour's Beef Cattle Improvement Research Project is a cooperative effort, making effective use of experts in each phase of the beef production cycle, from producer to retailer, to build into the beef cow those genetic characteristics of quality meat which will enable the industry to meet the requirements of today's specification buying. Some 23,000 range beef cows have been enrolled in the project since April 1958. The cattle were located on 42 ranches in 12 states. Of these, 15,000 were detected in heat and artificially inseminated with frozen semen from carefully selected performance and/or progeny tested sires. Most important factors in successful heat detection are (1) nutritional level of individual animals in various age, gestation, and lactation-phase classifications, (2) period of time elapsed since last calving, (3) permanent residence in a familiar pasture during entire period, (4) persistence, enthusiasm and cow-sense of those observing herd, and (5) physical-geographical layout of detection pastures. The percentages of available cattle detected in heat on the 42 ranches ranged from 33% up to 95%, most of the herds being observed for a 45-day period. In those herds where records of day to day calving in previous years are available for comparison, the conception rates, as determined by rectal palpation have been comparable to or better than those obtained by natural breeding during the same period of time. Observations to date point out that reproductive physiological patterns of the range beef cow may differ from the dairy cow in (1) uterine involution postcalving, (2) intensity of estrous period (both in duration in hours and clinical manifestation), (3) level of milk production which will suppress clinical estrous, (4) variation of days between calving and first heat, between successive heats, and (5) breed idiosyncracies.

40. THE EFFECT OF SIRE ON TENDERNESS OF BEEF LOIN STEAKS AS MEASURED BY A PANEL OF FAMILIES AND THE WARNER-BRATZLER SHEAR MACHINE. Ray H. Means and G. T. King, *Texas Agricultural Experiment Station.*

Loin steaks from 101 steers were tested for tenderness and other eating characteristics. Nineteen sires were represented in the study. The family panel consisted of 40 families from four income groups. A 9-point score card was used by the family panel. Tenderness scores for sires ranged from 6.4 to 8.1 as rated by the family panel and shear values of 6.3 to 22.3, when tested by the Warner-Bratzler Shear machine using ½ in. cores. Analysis of variance showed a significant difference ($P<0.01$) for tenderness between sires when tested by either the family panel or Warner-Bratzler Shear machine. An overall satisfaction rating was highly correlated with tenderness rating (0.904). Coefficients of correlations for panel ratings and tenderness values as measured by Warner-Bratzler Shear were all significant ($P<0.01$).

41. THE EFFECT OF NUTRITION AND AGE OF BEEF STEERS ON THE COOKING AND EATING CHARACTERISTICS OF THE MEAT. P. P. Graham, R. F. Kelly and J. P. Fonteñot, *Virginia Agricultural Experiment Station.*

A total of 144 steers were allotted to the following feeding regimen: Lot 1—Maintenance ration; Lot 2—Full feed of hay; Lot 3—Limited concentrates plus full feed of

hay; Lot 4—full feed of a fattening ration. Some of the steers from each lot were slaughtered after 5, 10, 16 and 23 months on test. Some from each lot were placed on pasture about 5 and 17 months after they had been on test and were slaughtered at the end of the grazing season. Taste panel and cooking data were collected on the 6–7–8 rib cut. Differences ($P<.01$) in total cooking losses and juiciness due to nutrition and to age were noted in the drylot fed steers. In the pasture steers total cooking losses increased with age but were not affected by previous drylot nutrition. Juiciness increased with level of nutrition in drylot and in pasture steers slaughtered after 23 months on test; there was no definite pattern of juiciness in the younger steers. There was a highly significant feeding regimen x age interaction for juiciness in both the drylot and pasture groups. Tenderness increased ($P<.01$) with increased levels of nutrition in the drylot steers; it was not significantly affected by age in either drylot or pasture groups. Pasture seemed to have an equalizing effect on tenderness since little difference was noted between previous drylot treatments in the grazing steers. Increased plane of nutrition or age decreased the Warner-Bratzler values of the samples from the drylot groups. In the pasture groups lower shear values were recorded for the steers slaughtered at 23 months of age; previous drylot nutrition had no marked effect.

42. FACTORS INFLUENCING BEEF TENDERNESS. N. B. Webb, O. J. Kahlenberg and H. D. Naumann, *Missouri Agriculture Experiment Station.*

Carcasses from 66 cattle 12, 24 and 60 months of age which differed in ante-mortem stress treatment, method of aging and grade were used to investigate differences in tenderness. Tenderness was evaluated at various times during aging by taste panel, chemical, and mechanical methods. Tenderness improved during aging and was associated with changes in pH, juiciness, water-holding capacity and water-extractable nitrogen and sodium, potassium, calcium, magnesium and phosphate. Steaks from non-stressed steers were significantly more tender than those from stressed steers during the early stages of aging. However, tenderness was similar for steaks from the stressed and non-stressed cattle at the termination of the aging period. The meat from young cattle was significantly more tender than that from old cattle. Panel tenderness values were significantly correlated with Warner-Bratzler shear values and hydroxyproline content of beef muscle. Significant correlations were also obtained between the Warner-Bratzler shear, a modified Kramer shear and a "cooked core" shear method.

43. PHENOTYPIC CORRELATIONS BETWEEN DIAMETER AND DENSITY OF HAIR AND TENDERNESS OF BEEF. T. C. Cartwright, *Texas Agricultural Experiment Station.*

Fifty-one steers averaging 14 months of age and 896 lb. live weight were slaughtered at the end of a 154-day, feed-lot period. The breeding groups and numbers were Hereford (H), n=9; Brahman (B), n=10; H x B ($F_1$), n=12; H x $F_1$, n=8; and B x $F_1$, n=12. Two random hair samples each of approximately 0.2 cm.$^2$ were pulled from the crops region the day before slaughter. The hairs of each sample were counted, and approximately 10% of the individual hairs from each sample were measured for diameter. The average density of 31,770 hairs was 311.57 per 0.2 cm.$^2$ and the average diameter of 2,533 hairs was 19.8 microns. Paired bottom round and loin steaks were cooked by both broiling and braising to two states of doneness. The average shear force of ½-in. cores from all steaks was 9.55 lb. The differences among breeds were significant for shear force of meat but not for diameter and density of hair. The within breed partial regression coefficients with shear force as the dependent variable were 0.03 for shear with diameter independent of density and 0.25 for shear with density independent of diameter. The multiple correlation was 0.27. These low, non-significant values indicate that the variation in hair density and diameter would be of little value in estimating tenderness.

44. THE EFFECT OF PERIODIC ELECTRIC SHOCK PRIOR TO SLAUGHTER ON THE EATING QUALITY OF FRESH AND CURED PORK. P. K. Lewis, Jr., C. J. Brown, and M. C. Heck, *University of Arkansas.*

Thirty-six market weight hogs were stratified according to weight and sex and allotted at random into two lots each of 18 pigs. One lot of pigs received periodic electric shock treatment for 5½ hours prior to slaughter while the other lot was placed in a pen and not disturbed during this period. Periodic electric shock treatment had no significant effect on the live shrink, amount of blood lost in bleeding, dressing percent, 24- and 48-hour cooler shrink, or 24-hour pH of the *Longissimus dorsi* muscle. Periodic electric shock treatment significantly increased the 24-hour pH of the *Psoas major* and *Quadriceps femoris* muscles, and significantly decreased the incidence of two-toneness of the ham. Family taste panel scores from the first six pigs of each treatment showed that periodic electric shock treatment significantly increased the tenderness score of fresh ham and significantly decreased the aroma score of the loin pork chop. Taste panel scores from the next six animals from each lot showed that stress significantly increased the texture score of the *Psoas major* muscle, and significantly increased the tenderness and juiciness scores of the *Psoas major* and *Quadriceps femoris muscles.* Taste panel scores from the last six animals in each lot showed that there was no significant effect of periodic electric shock treatment on the aroma, flavor of the fat and lean, texture, tenderness, and juiciness of commercially or dry cured hams.

45. THE INFLUENCE OF FREEZING ON SHEAR AND TASTE PANEL EVALUATIONS OF BEEF. J. L. McBee, Jr. and H. D. Naumann, *Missouri Agriculture Experiment Station.*

An investigation was conducted to determine the effects of freezing, temperature of freezing, storage period, and grade on beef tenderness as measured by organoleptic and mechanical methods and to establish the relationship between tenderness evaluation methods. From 48 short loins of two grades (U. S. Choice and U. S. Utility) 576 steaks were frozen at 20° F., 0° F., and —20° F. Evaluations were made for tenderness by taste panel and the Warner-Bratzler shear. Evaluations were made fresh, immediately after freezing, and at the end of 2 and 4 months storage. Freezing and frozen storage did not increase tenderness, but in some cases had a slightly adverse effect. Temperature of freezing did not measurably affect tenderness. Grade had a significant effect on tenderness, with a general trend toward lowered tenderness with lowered grade. The Warner-Bratzler shear (cooked) was significantly correlated with taste panel scores. The Warner-Bratzler shear (raw) was of less utility for measuring tenderness. There was greater variability in the shear values for raw samples than in those for cooked samples.

46. AN INVESTIGATION OF COLD WATER STRESS AS A PRESLAUGHTER TREATMENT ON CERTAIN CHARACTERISTICS OF PORK MUSCLE. R. N. Sayre, E. J. Briskey, W. G. Hoekstra and R. W. Bray, *University of Wisconsin.*

Eighteen market weight barrows which were self-fed a 12% protein, fattening ration were used in the first experiment. Three treatments were used: (1) Control, (2) 30 minutes cold water bath and slaughter 10 minutes after termination of stress, (3) stressed as in (2) and slaughtered 3 hours after treatment. In the second experiment 25 market weight gilts were self-fed a 50% sugar ration for 14 days prior to being subjected to the following five treatments. Lot 1 was held off feed 24 hours prior to slaughter, whereas Lot 2 was fasted for 12 hours. The remaining lots were fasted for 12 hours prior to a 40-minute treatment in a cold water bath. Lot 3, 4 and 5 were slaughtered respectively 20 minutes, 3 hours and 12 hours following treatment. Results

of experiment I showed that the visual color score of the chilled ham butt was significantly darker in Lot 2 than in Lot 1. In experiment II color score was significantly darker in Lots 3 and 5 than in Lot 2. Also, glycogen content of the fresh gluteus medius muscle was significantly higher in Lot 2 than in Lot 5. Significant positive correlations were found in the two experiments between color score and both chilled pH and visual wateriness score. Significant negative correlations were found between gluteus medius glycogen and chilled pH, color and wateriness score. The following positive correlations were found in experiment I: gluteus medius glycogen and liver glycogen (0.51) and chilled expressible juice (0.54); significant negative correlations were obtained between chilled expressible juice and color score (—.77) and wateriness score (—.64).

47. CORRELATIONS AMONG VARIOUS CRITERIA EMPLOYED IN BEEF CARCASS EVALUATION. T. N. Blumer, H. B. Craig, H. P. Fleming, E. R. Barrick and M. B. Wise, *North Carolina Agricultural Experiment Station.*

Approximately 300 cattle carcasses were evaluated during the years 1954–1958. These cattle were of about the same breeding each year and were fed under controlled feeding and nutrition experiments consisting of pasture only; pasture and grain; pasture, grain and stilbestrol; and pasture, grain, stilbestrol and animal fat. The cattle were slaughtered at a specified grade or weight. Values obtained from each carcass that were included here are shrunk live weight, carcass weight, measured marbling deposits, separation of fat, lean and bone of 9–10–11 rib section, area of ribeye, pigment content, Hunter color and color difference meter, visual color, and carcass grade. Simple correlations were determined on IBM irrespective of treatment, and also by correcting for treatment. Space will permit only examples of correlation values: marbling measurements vs. % separable fat, 0.20; ether extract, 0.31; and carcass grade, 0.31. Myoglobin vs. Hunter Rd. scale, —.49; Hunter A scale, 0.31; Hunter B scale, 0.16; visual color, —.125. By treatments: Carcass weight vs. area of ribeye, on stilbestrol, 0.54; stilbestrol and fat, 0.22; pasture, 0.46; and grain, 0.30. Area of ribeye vs. carcass grade, on stilbestrol, 0.28; stilbestrol-animal fat, —.06; pasture, 0.29; and grain, —.26. Stilbestrol reduces the amount of carcass fat. Stilbestrol-fat increases the amount of carcass fat.

48. EVALUATION OF CARCASSES SIRED BY LONG BODIED AND SHORT BODIED BULLS. V. R. Cahill, B. D. VanStavern, L. E. Kunkle and Earle W. Klosterman, *Ohio State University.*

Thirty Hereford steers and heifers sired by three long bodied and three short bodied bulls provided the source of these data. Carcasses were appraised by grade, length and depth measurements, rib eye area, edible portion (includes muscle and a maximum of $\frac{3}{8}$″ fat on any exposed surface) of the right side, and physical analysis of the 9–11 rib cut. Metacarpal, metatarsal, humerus and femur bones were weighed and measured in search of a readily available indicator of muscling. In comparing the two groups of cattle, significant differences exist in weight of edible portion and bone of the right side, of separable muscle of the 9–11 rib cut and in length and volume of long bones. Adjustment of data to a constant unit weight of carcass removes these differences from significance. A highly significant correlation (0.925) exists between weight of femur and weight of edible portion of the carcasses sired by short bodied bulls. Weights of other long bones correlate positively with edible portion data as does separable muscle of the 9–11 rib section and total edible portion of the side. The rib eye area-edible portion correlation was 0.684. These data indicate that high correlations exist between weights of long bones and weight of edible portion but if these data are reduced to a percentage basis the differences are not significant. Likewise, only small carcass differences exist between sire groups when adjustment is made for weight variation.

49. A NEW METHOD OF CUTTING BEEF CARCASSES TO DETERMINE ACCURATELY THE YIELD OF RED MEAT IN THE CARCASS. G. T. King, O. D. Butler and L. D. Wythe, Jr., *Texas Agricultural Experiment Station.*

One hundred twenty steer carcasses ranging in weight from 204 to 745 lb. were cut by the standard method recommended by Wellington (1953). Carcass grades ranged from U. S. Standard to U. S. Choice Five breeds and 11 breed crosses were represented in the study. Each standard wholesale cut was given a "retail trim," which consisted of trimming all exterior fat to ¼ in. The flank side of the loin was removed by cutting just below the obliqus abdominis internus muscle on the rib end, cutting straight to the upper edge of the tensor fasciel latal muscle on the sirloin end. Short ribs were removed from the prime rib by cutting from the ventral edge of the longissimus costarum on the loin end to a point 2 in. from end of the scapula bone. The thoracic vertebra was closely trimmed. Shank was removed from the round and boned. English cut was removed from the chuck and the neck removed at the 3rd cervical vertebra and boned. Thoracic vertebra was closely trimmed. A uniform fat trim was made on the brisket, plate, flank, and short ribs. The foreshank was boned. The average percent of loin, rib, round, rump on was 47.82% by the standard method of cutting as compared to 37.25% for the "retail trimmed" method. Highly significant differences were observed when measured by the "retail trimmed" method, whereas by the standard cutting method little or no significance was observed.

50. PREDICTING TOTAL CARCASS LEAN IN MATURE BEEF USING WEIGHTS OF CERTAIN ENTIRE MUSCLES. L. E. Orme, J. W. Cole and C. M. Kincaid. *University of Tennessee.*

The amount of lean in a carcass is of particular importance in sire testing programs, carcass evaluation studies and to the ultimate consumer preference for a certain cut of beef. Physical separation of the entire carcass is laborious and costly. Therefore a simple indirect method for predicting total separable carcass lean would be extremely useful. The *Biceps femoris, Semitendinosis, Psoas major, Longissimus dorsi, Infrapinatus, Triceps brachii,* the inside round muscles, (*Semimembranosus* + *Adductor*) and the major muscles of the sirloin tip (*Vastus lateralis* + *Vastus intermedius* + *Vastus medialis* + *Rectus femoris*) were each excised from the left side of 43 mature beef cows (9½ to 11 years), cleaned of all external fat and weighed. The remaining lean, fat and bone from each left side was physically separated and weighed. The weights of the previously mentioned muscles were found to be associated with 63 to 92% of the variation existing in the weight of total separable carcass lean. Simple correlation coefficients between the weight of separable carcass lean and the weight of the various muscles or groups of muscles were as follows: 0.957 *Biceps femoris,* 0.931 sirloin tip, 0.919 inside round, 0.917 *Longissimus dorsi,* 0.843 *Triceps brachii,* 0.832 *Semitendinosis,* 0.820 *Psoas major* and 0.795 *Infraspinatus.* Standard partial regression coefficients, holding live animal weight constant and regression equations were calculated using the above individual muscles or muscle groups.

51. CANNON BONE CHARACTERISTICS AS RELATED TO MUSCLE IN BEEF CARCASSES. Frank A. Orts and G. T. King, *Texas Agricultural Experiment Station.*

Muscle-bone data were collected on 66 Hereford steers to determine the relationship of certain bone characteristics to muscling in the beef carcass. Steers were divided into age groups and gross simple and partial coefficients of correlation were calculated between the length, weight, area and weight-length ratio of the Metacarpus and Metatarsus bones. Bone weight and weight-length ratio were found to be more highly correlated to wholesale cut weights (0.870 and 0.880), ribeye area (0.800 and

0.800) and chilled carcass weight (0.950 and 0.867) than was length and area. However, length and area had a positive significant relationship to all wholesale cut weights (0.700 and 0.675), ribeye area (0.630 and 0.700) and chilled carcass weight (0.700 and 0.695). Shear force value, as measured by the Warner-Bratzler Shear Machine, was positively and significantly correlated to all bone measurements (r=410). These correlations were all significant at the $P<0.01$ level.

52. RELATIONSHIP OF OBJECTIVE MEASUREMENTS OF THE LONGISSIMUS DORSI MUSCLE IN LIVE LAMBS TO CARCASS MUSCLING CHARACTERISTICS. D. J. Matthews, R. A. Merkel, J. D. Wheat and R. F. Cox, *Kansas State University.*

Eighty-six lambs from two separate trials were used to study the relationship between cross-sectional dimensions of the longissimus dorsi muscle and fat depth estimates in live lambs and carcass characteristics. Depth of the longissimus dorsi muscle was estimated by a needle probe over the right transverse process of the second lumbar vertebra. Width was estimated by halving the caliper measurement between the lateral extremities of the transverse processes of the second lumbar vertebra. An estimate of cross-sectional area of the longissimus dorsi muscle was recorded as the product of the width and depth estimates. Partial correlation coefficients, with live weight held constant, were calculated. Correlations between depth estimate of the longissmus dorsi muscle and actual depth of the muscle were 0.43 and 0.62, respectively, in the two trials. Highly significant correlations of 0.56 and 0.59 were obtained between depth estimate and cross-sectional area of the muscle (planimeter reading) in the two trials. Estimated width was nonsignificantly correlated, 0.15 and 0.30, with actual width of the muscle. Correlations between estimated cross-sectional area and actual area were 0.55 and 0.69 in trials 1 and 2, respectively. The correlation between depth estimate and actual area of the muscle was almost as high as that between estimated area (width x depth estimate) and actual area. In general, cross-sectional measurements of the longissimus dorsi muscle were not as highly correlated as were fat measurements with either percentage wholesale cuts or separable lean in the rack.

53. THE RELATIONSHIP BETWEEN THE POTASSIUM ISOTOPE, $K^{40}$ AND MEATINESS OF LIVE HOGS. S. E. Zobrisky, H. D. Naumann, A. J. Dyer and E. C. Anderson, *University of Missouri.*

A study was conducted to determine the utility of the naturally occurring isotopic potassium, ($K^{40}$), as a quantitative measure of the muscle mass in live hogs, carcasses and wholesale cuts. The water, before and after scalding, various internal organs and bones were also analyzed for radioactivity, employing a four pi liquid scintillator (Humco I), to determine their possible contribution to total isotopic potassium activity of live hogs and portions thereof. Results from this study indicate that $K^{40}$ content may possibly have use as a rapid, non-destructive index for determining protein:fat ratios in the livestock and meat industry.

54. THE RELATIONSHIP OF SPECIFIC GRAVITY TO CARCASS COMPOSITION OF BEEF STEERS FROM DIFFERENT LEVELS OF NUTRITION AND OF DIFFERENT AGES. R. F. Kelly, J. P. Fontenot, P. P. Graham, and W. S. Wilkinson, *Virginia Agricultural Experiment Station.*

In each of 2 years, 72 steer calves were started on the following levels of nutrition in drylot: Lot 1—Maintenance; Lot 2—Full feed of hay; Lot 3—Limited concentrates plus full feed of hay; Lot 4—Full feed of a fattening ration. Some steers from each lot were slaughtered after they had been on test about 5, 11, 17, and 23 months. Some

from each lot were placed on pasture about 5 and 17 months after they had been on test and were slaughtered at the end of the grazing season. After slaughter and a 48–72 hour chill specific gravity (Sp. G.) was determined on 10 wholesale cuts. The meat (lean and fat) was separated from the bone and sampled for proximate analysis. Correlations of Sp. G. with percent moisture, percent fat (ether extract), and percent protein were determined within nutrition treatments and age groups. In carcasses from the drylot-fed cattle on low level of nutrition (Lot 1) the correlation coefficients ("r" values) of Sp. G. with percent fat, percent moisture, and percent protein usually were low and not statistically significant. In the drylot steers at the higher levels of nutrition (Lots 2, 3, 4) the corresponding "r" values were higher, in general, being highly significant. In carcasses from the pasture groups the "r" values for Sp. G. with percent fat, percent moisture, and percent protein usually were highly significant. From these data it apepars that the use of Sp. G. for estimation of fat, moisture, and protein in meat is probably not reliable in cuts of beef with very low fat content.

55. THE RELATIONSHIP OF LUMBAR LEAN MEASUREMENTS TO PORK CARCASS MUSCLING. R. G. Kauffman, R. W. Bray and D. E. Goll, *University of Wisconsin.*

Well muscled hams and large shapely loin eyes contribute to pork carcass muscling and therefore it is desirable to find certain guides which may indicate these factors of carcass conformation. The lumbar lean area is exposed between the fatback and the lumbar processes in the split carcass. The multifidus dorsi and piriformis muscles represent the lean area. Three measurements were taken including a depth measure (from the ventral portion of the veretbral foramen of the last lumbar vertebra to the inner portion of the fatback), an area tracing, and a visual score observation. These were compared to loin eye area, lean cut yield, ham weight, and loin weight, holding carcass weight constant. Simple, partial, and multiple correlations were computed using 304 carcasses representing nine breeds from five carcass contests. The results of this investigation showed that after adjusting for carcass weight the depth measurement and area determination were highly associated with loin eye area ($r = 0.361$ and 0.474) and that lumbar depth was highly related to lean cut yield ($r = 0.544$). However, lumbar scores exhibited no relationship to the various muscle traits. Some differences existed among breed response to the lumbar measurements. Four of the breeds gave highly significant results between lumbar depth and loin eye area. In addition, ham weight, adjusted for carcass weight, accounted for 20% of the variation in loin eye area and 76% of the variation in lean cut yield.

56. URINARY CREATININE AS A MEASURE OF MEATINESS IN BARROWS. S. E. Zobrisky, W. L. Swisher, A. J. Dyer and H. D. Naumann, *University of Missouri.*

Forty barrows were used in a study designed to determine the relationships between urinary creatinine coefficients and carcass meatiness. Total urine excretions were collected twice daily for 3 consecutive days by employing either a portable harness or a metabolism crate. Correlations between creatinine coefficients calculated from afternoon urinary excretions and measures of carcass meatiness were of larger magnitude than similar correlations from the morning urinary excretions. The portable harness was superior to the metabolism crate for collecting urine. Correlations between creatinine coefficients and measures of carcass meatiness were as follows: lean cuts, 0.48; 10th rib loin eye area 0.26; last rib loin eye area 0.58; backfat thickness —.67. The creatinine coefficients calculated from urine collected on the second day yielded the most significant results when correlated with measurements of carcass meatiness.

57. RELATIONSHIP BETWEEN SLAUGHTER AND CARCASS GRADES IN BEEF CATTLE. J. D. Wheat and L. A. Holland, *Kansas State University*.

Members of the Department of Animal Husbandry independently graded 688 Hereford heifers and steers to the nearest ⅓ grade just before slaughter. The animals in the 15 groups were 20 to 22 months old and had been fed 100 to 154 days when slaughtered. Graders per group ranged from 3 to 10 and averaged 6.60. No group was graded by all 12 graders. After cooling 24 to 48 hours, each carcass was graded to the nearest ⅓ grade by a U.S.D.A. Federal Grading Service official. Eighty-one percent of the after ribbing carcass grades ranged from average good to average choice. Weighted average correlations between slaughter grade and carcass conformation grade ranged from 0.23 to 0.51. All were highly significant except the 0.23, which was significant. All average correlations between slaughter grade and before ribbing carcass grade were highly significant. They ranged from 0.28 to 0.55. Average correlations between slaughter grade and after ribbing carcass grade ranged from 0.07 to 0.39. All except two were highly significant and only 0.07 was nonsignificant. Repeatability of slaughter grade was calculated for each group of cattle and the weighted average of these intraclass correlations was 0.50. Average correlations between carcass conformation and before ribbing carcass grade, after ribbing carcass grade, and degree of marbling were 0.42, 0.25, and 0.25, respectively. Average correlations between before ribbing carcass grade and after ribbing carcass grade, and degree of marbling were 0.53 and 0.45. Average correlation between after ribbing carcass grade and degree of marbling was 0.89.

58. CARCASS CHARACTERISTICS AND CUT-OUTS OF SOME DIFFERENT BREEDS OF SWINE. A. M. Pearson, W. T. Magee, L. J. Bratzler and J. A. Hoefer, *Michigan State University*.

Backfat thickness, carcass length, area of loin-eye and percentage of the various trimmed wholesale cuts were obtained for purebred Berkshire, Poland China, Tamworth, Hampshire, Chester White, Duroc and Yorkshire hogs slaughtered in our laboratory. Highly significant differences occurred between some breeds for all traits investigated. It is evident from the data available that relative breed rank for lean or primal cuts is not a true reflection of actual value. Different breeds had a high percentage of certain wholesale cuts such as the loin or ham, whereas others attained their relative rank by virtue of a high percentage of shoulder or belly. Breed rankings tended to be similar regardless of whether cut-outs were calculated on a live or carcass basis. Ranking on area of the loin-eye and on lean cuts by breeds showed marked inconsistencies, indicating that loin-eye does not closely reflect actual cut-outs. Similarly, backfat thickness or carcass length rankings by breeds did not closely parallel similarly rankings for lean or primal cut-out.

59. COMPOSITION OF THE CARCASSES OF BOARS, BARROWS AND GILTS AT THREE STAGES OF DEVELOPMENT AND THE INFLUENCE OF IMPLANTING STILBESTROL. V. R. Cahill, H. S. Teague, E. A. Rutledge, L. E. Kunkle and A. L. Moxon, *Ohio Agricultural Experiment Station*.

Four phases of experimentation in support of the title have been accomplished. Phase I was a study of development, by sex, through a range of 100 lb. to 210 lb. live weight. Differences in the lean-fat ratio become most obvious at the 150-lb. weight and higher. Likewise, the boar meat became less palatable as the animals grew beyond the 150-lb. weight. The second and third phases were designed to study the characteristics of gilts and barrows slaughtered at 150 and 210 lb. and the influence of stilbestrol implants on barrow growth and carcass composition. Stilbestrol ear implants of either 1½ mg., 3 mg. or 6 mg. at 150 lb. had little effect in either growth rate or feed utilization.

Positive relationships existed between amount of stilbestrol implanted and both size of rib eye and percent of primal cuts. The cross section area of longissimus dorsi was measured at three points, the muscle was weighted and the edible portion of ham and shoulder was determined in addition to trimmed primal cut weights. These data suggest that the 10th rib area is as accurate as the average of three areas or weight of the longissimus muscle is predicting weight of primal cuts. Various methods of influencing the sexuality of boars were tested during Phase IV.

60. ULTRASONIC MEASUREMENT OF FAT THICKNESS AND LOIN EYE AREA ON LIVE CATTLE AND HOGS. J. R. Stouffer, M. V. Wallentine and G. H. Wellington, *Cornell University*.

The depth and area of *longissimus dorsi* muscle and thickness of subcutaneous fat have been determined with ultrasonic equipment on approximately 100 cattle and 40 hogs. Measurement of rib eye area on live cattle was accomplished by first determining the outline of the external curvature over the last rib with solder wire. Then individual soundings at known angles of incidence were taken at ½-in. intervals over the last rib. The readings were then plotted and depth and area measurements taken. To date, the results indicate that fat thickness and rib eye area can be accurately measured with ultrasonic equipment as shown by a close relationship of a plotted outline made ultrasonically the live animal with a tracing from between the 12th and 13th rib of the carcass. A similar technique used on live hogs also indicated a close relationship of backfat thickness and loin eye area at the 12th rib on live hogs with a tracing of a cross section of the rough loin at the same location on the carcass.

61. THE USE OF ULTRASONICS TO ESTIMATE THE SIZE OF THE LONGISSIMUS DORSI MUSCLE IN SHEEP. Dudley Campbell, H. H. Stonaker, and A. L. Esplin, *Colorado State University*.

Depths of the right and left longissimus dorsi muscles over the last ribs on 65 sheep have been estimated with an ultrasonic device, the somascope. The animals were divided into two separate groups, one comprised of 32 lambs, the other composed of 33 lambs. The wool was clipped and then shaven from the area to be scanned. Soundings were obtained at 1 in. and 1½ in. and 2 in. off the spinal column on right and left sides. The animals were then slaughtered and tracing made of the rib eye muscle. From these tracings the rib eye area and depth measurements at the three locations were obtained. When the sum of the total of the somascope readings of rib eye depth was correlated with the corresponding value for the tracing depth, correlations of 0.68** and 0.49** were obtained for groups 1 and group 2, respectively. The sum of somascope measurements and rib eye area was correlated. Significant values of 0.62** for group 1 and 0.44** for group 2 were obtained. Rib eye area and total tracing depth were significantly correlated, with values of 0.76** for group 1, and 0.79** for group 2.

62. EFFECT OF VARIATIONS IN DIETARY ENERGY DENSITY ON CARCASS VALUE IN SWINE. R. F. Sewell and J. L. Carmon, *University of Georgia*.

Three replications of six pigs each were allotted to each of four treatment groups. Treatments were as follows: (1) high energy ration fed throughout the growing-finishing period; (2) high energy ration fed during the growing period to average weights of 110 lb. with a low energy ration being fed during the finishing period from 110 lb. to market weights; (3) low energy ration fed during growing period with high energy ration fed during finishing period; (4) low energy ration fed throughout the growing-finishing period. Energy levels were varied by manipulation of stabilized tallow and ground oats in the ration formulas. Pigs receiving treatment (1) gained at a significantly faster rate than did pigs receiving either of the other treatments. Pigs receiving

treatment (1) also showed greater efficiency of feed utilization. Slaughter data were obtained on each pig. No significant differences were found between treatment with regard to carcass length, backfat thickness, percent loin, percent ham, percent shoulder or percent of total lean cuts. Based on live weight at slaughter the percent yield of trimmed lean cuts was as follows: treatment (1) 37.67%; treatment (2) 37.49%; treatment (3) 37.21% and treatment (4) 37.54%. A slightly higher dressing percent was found for the pigs receiving treatment 1.

63. THE RELATIONSHIP BETWEEN GROWTH, CARCASS AND MEAT CHARACTERISTICS OF LITTERMATE BOARS, BARROWS, GILTS AND SPAYED GILTS. S. E. Zobrisky, L. F. Tribble, J. F. Lasley and H. D. Naumann, *University of Missouri.*

Sixty-four hogs were divided into four sex groups (boars, barrows, gilts, and spayed gilts). Each of the four sex groups consisted of 12 Landrace X Poland China crosses, two Landrace and two Poland Chinas. Carcass measurements, yield of wholesale cuts and separable lean, fat, and bone data were statistically analyzed to determine the differences between sexes and among littermates. The boars had greater length of leg, ($P<0.01$); width of shoulder, ($P<0.01$); ham lean area, ($P<0.01$); loin eye area, ($P<0.01$); yield of four lean cuts, ($P<0.01$); and yield of bone ($P<0.01$) than did littermate barrows, gilts or spayed gilts. No statistical differences were found between littermates in regard to length and depth of carcass. The barrows were the most highly finished followed by the spayed gilts, gilts and boars. The 16 quadri-groups of littermates did not differ significantly in weight at birth, weaning (56 days of age) or slaughter (166 days of age).

64. EFFECT OF MODERATE VS. RAPID RATES OF GAIN ON EFFICIENCY OF FEED CONVERSION AND CARCASS COMPOSITION OF STEER CALVES. R. F. Hendrickson, R. L. Henrickson, L. S. Pope and George O'dell, *Oklahoma Agricultural Experiment Station.*

In three trials, 64 weanling steer calves from one experimental cow herd and sired by closely related bulls were individually fed to make 400 lb. total feedlot gain either (a) rapidly, (b) moderately, (c) rapidly for 200 lb. and then moderately, or (d) moderately for 200 lb. and then rapidly. Average daily gains were 1.91 lb. and 1.52 lb. for rapid and moderate groups, respectively. Data obtained included feed efficiency, body measurements, and final live grades. Slaughter data included stomach contents, carcass measurements and yield, grade, marbling score, rib eye area and fat thickness, wholesale cuts and their specific gravities, 9–10–11 rib composition, shear values and taste panel scores. Calves fed to gain moderately required about 60 days longer to reach final weight and were no more efficient than full-fed calves due to a longer feeding period. Moderate gaining calves graded lower, had less external fat and marbling, but contained about 6% more lean. Yield of wholesale cuts per cwt. of carcass was little affected by treatment. None of the feeding regimes had a marked effect on shear values or tenderness scores. Altering rate of gain during the last half of the feeding period gave results similar to calves fed for the same rate of gain throughout. The rapid-moderate system appeared to be the least desirable, based on feed efficiency, rate of gain, and carcass quality, while the moderate-high regime showed considerable promise under these conditions.

65. INFLUENCE OF SLAUGHTER WEIGHT ON ECONOMY OF PRODUCTION AND CARCASS VALUE OF SWINE. H. D. Wallace, G. E. McCabe, A. Z. Palmer, M. Koger, J. W. Carpenter and G. E. Combs, *University of Florida.*

Two trials, involving a total of 128 pigs of mixed breeding and four slaughter weights (150, 180, 210 and 240 lb.), were conducted. Daily gains were 1.44, 1.48, 1.53

and 1.52 lb. for the respective weight groups. Feed requirements per lb. gain were 3.17, 3.24, 3.33 and 3.41 lb. Dressing percentages based upon empty digestive tracts were 73.8, 74.1, 74.8 and 75.9. Backfat thicknesses (in.) were 1.12, 1.26, 1.47 and 1.51. Loin eye areas (sq. in.) measured at tenth rib were 3.43, 3.85, 4.07 and 4.47. Percent lean cuts were 53.77, 53.35, 51.06 and 49.33. Barrows gained significantly faster than gilts ($P < 0.01$), however, gilts had less backfat ($P < 0.01$) and significantly larger loin eye muscles ($P < 0.01$). Variations in loin eye muscle shapes between breeds were observed.

66. THE PHOTOMETRIC MEASUREMENT OF CARCASS CROSS SECTIONAL AREAS DIRECTLY FROM PROJECTED POLAROID TRANSPARENCIES. R. J. Deans, L. J. Bratzler, and D. C. Price, *Michigan State University*.

Polaroid projection transparencies provide for the examination for accuracy of photographic results prior to the disposing of the meat carcasses and cuts being studied with a minimum of time required for the adaptation of the polaroid projection transparency to the direct measurement of cross sectional areas. Results have been obtained using a 4 x 5 Graflex Crown Graphic camera equipped with a Polaroid Land back and using type 46-L Polaroid projection transparencies. For expediency and accuracy, camera-to-subject distances and subject location have been fixed and a scale mounted in plane with the surface to be photographed. A standard 3¼ x 4 slide projector is used in combination with a mirrored surface placed at 45° with respect to the horizontal projector axis. Thus, the projected image is changed 90° and projected to the under side of a plate glass surface mounted in a horizontal plane. Measures are then made using a planimeter directly on acetate film placed on the top surface of the plate glass. Studies have shown accuracy of reproduction to within 0.5 mm. of actual metal block measurements. A study of reproducibility on sample lamb loin cross sections has shown standard deviations in L. dorsi area of 0.06 sq. in. and of 0.070 mm. in external fat thickness with the photometric method as compared to standard deviations of 0.24 sq. in. in area and 0.276 mm. in external fat thickness using standard tracing techniques. The Polaroid transparency thus records both quantitative as well as qualitative cut surface characteristics.

67. PHOTOGRAPHIC METHOD OF MEASURING LOIN EYE AREA. J. E. Corbin, J. L. Williamson, H. B. Geurin, and H. L. Wilcke, *Ralston Purina Company*.

A method for the measurement of loin eye area using a simplified photo-measurement technique has been developed. Photographs of loin eyes are projected by the use of a mirror to a calibrated ground glass table top and measured with a planimeter. Data are presented comparing measurements by conventional tracings and the photographic technique. Slides demonstrate the method of taking pictures through a grid system and the projection of the colored transparencies for measurement. The method is accurate, efficient, economical, uncomplicated, and can make use of almost any 35 mm. camera and projector.

68. MICROBIOLOGICAL TECHNIQUES FOR THE DETERMINATION OF RANCIDITY IN PORK FAT. Boyd Ramsey and James D. Kemp, *University of Kentucky*.

A microbiological method was developed for determining rancidity in uncured pork fat. Fat samples of varying rancidity were prepared by pumping dry air through heated fat and withdrawing samples at 30-minute intervals. An agar medium at pH 6.8 was blended with a 5.5% concentration of fat, inoculated with *Bacillus subtilis* spores, poured into petri dishes, and incubated for 14, 16, 20, 32, and 48 hours at 37° C. Fresh fat gave increased colony counts over controls containing no fat. Very rancid fat gave complete inhibition of spore germination through 20 hours incubation. Colony counts

decreased as rancidity increased and increased with longer incubation periods. Correlations for colony counts at 20 hours incubation were 0.94 for iodine number ($P<0.01$), —.95 for peroxide number ($P<0.01$), and —.19 for free fatty acid content of the fat samples. Colony counts in petri dishes were highly correlated ($P<0.01$) with colony counts on test tube slants. The latter method greatly reduced time and materials needed to assay a sample.

69. PORK MUSCLE COLOR AS MEASURED BY DISK COLORIMETRY AND MYOGLOBIN CONCENTRATION. W. E. Henry and L. J. Bratzler, *Michigan State University.*

Two trials were conducted with 36 purebred Hampshire and 44 crossbred hogs to determine the effects of breed, and zinc, iron and copper supplementation on color and myoglobin content of pork muscle (sections of the *Longissimus dorsi*). Surface color measurements were made with Munsell spinning disks, and myoglobin values were determined spectrophotometrically. Analysis of variance indicated no significant effect of mineral supplementation upon myoglobin concentration of the *Longissimus dorsi.* (Trial I. $F=0.30$; Trial II, $F=0.45$). In addition, non-significant relationships were found upon comparing breed to the myoglobin concentration of fresh sample ($F=0.42$) and myoglobin concentration on fat-free, moisture-free basis ($F=2.62$). The latter comparison approached significance. By use of the correlation coefficient, highly significant relationship was found between index of fading and myoglobin concentration ($r=-.69$) indicating the feasibility of using the Munsell spinning disks as a method of predicting myoglobin content of pork muscle. Non-significant correlation coefficients were obtained upon comparing index of fading with ether extract (0.21) and total moisture (—.16). Correlation coefficients obtained upon comparing myoglobin concentration to ether extract and total moisture were non-significant (—.29 and —.13, respectively). The results indicated a very low relationship between fat and moisture content of pork muscle and its color as measured spectrophotometrically or by disk colorimetry.

70. EFFECT OF ZYMOSAN ON GROWTH RATE, FEED EFFICIENCY AND IMMUNOLOGICAL RESPONSE IN BABY PIGS. H. Brown, V. C. Speer, L. Y. Quinn, J. D. Jones, V. W. Hays and D. V. Catron, *Iowa State University of Science and Technology.*

Three hundred and ten baby pigs were used in eight experiments to study the effects of the injection of zymosan, a residue of baker's yeast after autolysis, trypsin digestion and alcoholic precipitation. The over-all average effect on growth rate and feed efficiency was an improvement of 11.2% and 4.9% respectively. Three of these experiments involving 96 pigs were conducted under relatively disease-free conditions. There was no difference in growth rate or feed efficiency as a result of injections of zymosan. In contrast, 214 pigs were used in five experiments where the disease level would be accepted as being greater. The pigs treated with zymosan had an average improvement of 16% and 6.0% for growth rate and feed efficiency, respectively. Levels of 0, 2.5, 5.0 and 10.0 mg. of zymosan per kg. of body weight were tested and the optimum level appeared to be between 2.5 and 5.0 mg. per kg. of body weight. The control (0 level) pigs were injected with physiological saline solution. Simultaneous injections of zymosan plus various bacterins resulted in higher serum antibody titers when combined with *Serratia marcescens* and *Candida albicans* but not with *Escherichia coli.*

71. THE INFLUENCE OF INGREDIENTS AND PROCESSING ON THE CONSUMPTION OF EARLY CREEP FEED BY THE PIG. H. S. Teague and E. A. Rutledge, *Ohio Agricultural Experiment Station.*

In four seasons 158 litters were used in trials to determine the influence of various ingredients on the palatability of early creep feed. A simplified feed containing 66%

rolled oats, 33.1% cracked corn, 0.4% trace mineralized salt, 0.5% antibiotic supplement and 5.68 gm. antioxidant was used as the basal creep feed. Changes in formulation or feed treatment included the substitution of 4% dried fish solubles, 10% dried skimmilk, 1% ground limestone and 1% steamed bone meal, 10% lard, 5% molasses, 10% cane or corn sugar, 1 lb. saccharin per ton, 9.14 lb. calcium cyclamate (Sucaryl) per ton and the cooking or expanding of the basal feed. Ingredients were substituted for rolled oats and corn in the basal feed maintaining a ratio of two parts rolled oats to one part corn. Consumption was measured from the 14th to 35th day. In the four seasons the amount of feed eaten per pig ranged from as little as 0.8 lb. of the basal feed to as much as 7.86 lb. where 4% dried fish solubles were substituted. The greatest variation in consumption occurred between seasons and appeared to be related to the prevailing weather conditions. Only the substitution of 10% lard, 4% dried fish solubles and 1% each of ground limestone and steamed bone meal appeared to increase the palatability of the basal feed in all seasons. Acceptability was also improved by the cooking or expanding of the basal feed.

72. EFFECT OF PROTEOLYTIC ENZYME SUPPLEMENTATION TO SIMULATED-MILK DIETS ON WEIGHT GAINS AND PROTEIN DIGESTIBILITY IN BABY PIGS. J. H. Maner, W. G. Pond and R. S. Lowrey, *Cornell University*.

Forty-four baby pigs were used in two growth-digestion trials to study the effects of pepsin and trypsin supplementation to soya-protein, simulated-milk diets and to compare casein and soya-protein as protein sources. Pepsin (1–10,000) was added to the feed at the time of feeding and at a rate of 1% of the dry matter, and trypsin (4x U.S.P. pancreatin) at a rate of 0.5% of the dry matter of the diet. The animals were control-fed the liquid, 28% protein, simulated-milk diets four times per day and were housed individually in metal brooders 2 ft. by 4 ft. equipped with thermostatically controlled heating units. In the first trial the average weight gains (lb.) and protein digestibility (%) for the 22-day experimental period from birth to 22 days of age were as follows: Lot 1 (soya) 2.6, 89.8%; Lot 2 (soya + pepsin) 2.6, 90.9%; Lot 3 (soya + trypsin) 2.6, 90.6%; Lot 4 (soya + pepsin + trypsin) 2.6, 90.3%; Lot 5 (soya + pepsin in gelatinous capsule) 2.3, 89.0%; and Lot 6 (casein) 3.3, 96.6%. In the second trial the average weight gains (lb.) for the 24-day experimental period from 4 to 28 days of age were as follows: Lot 1 (soya) 4.0, Lot 2 (soya + pepsin) 4.2, Lot 3 (soya + pepsin + trypsin) 4.3, and Lot 4 (casein) 5.5. Enzyme supplementation had no significant effect on protein digestibility or on weight gains. Casein, however, proved superior in its ability to produce weight gains, and the average casein digestibility was 7.2% higher than the average soya-protein digestibility.

73. EFFECT OF ARTIFICIAL FLAVORS ON PALATABILITY OF PIG STARTER DIETS AS MEASURED BY FREE-CHOICE FEED INTAKE. F. Diaz, L. E. Grinstead, V. W. Hays, V. C. Speer and D. V. Catron, *Iowa State University of Science and Technology*.

One hundred and twenty-eight two-week-old pigs were used to evaluate seven variations (101, 102, 103, 104, 105, 106, 107) of Sucroflavor, a commerical pig flavor compound made up of natural and artificial flavors. Saccharin and sodium cyclamate were included in each experimental flavor combination to provide sweetness equivalent to 10% sucrose, except for flavors 102 and 101 which were equivalent to 15 and 20% sucrose, respectively. The control diet contained 15% sweet dried whey (70% lactose). Flavor 101 was also added to a diet containing no dried whey and offered simultaneously with the control diet. The pigs were randomly allotted from littermate outcome groups, four pigs per pen and four pens for each flavor evaluation. One feeder containing the control diet and one with the control diet plus the experimental flavor were placed in

each pen. The feeders' positions were interchanged within pens three times per week. The pigs consistently preferred two of the seven flavor combinations over the basal diet. The consumption of flavors 102 and 104 represented 58 and 56% of the total feed consumed, respectively, from 2 to 8 weeks of age. When average consumption of all flavored diets was compared to the consumption of each flavor diet, pigs consumed 16, 4, 22, and 13% more of diets containing flavors 102, 103, 104, and 105, respectively, from 2 to 5 weeks of age. From 5 to 8 weeks of age, pigs consumed 35 and 20% more of flavors 102 and 104. From 2 to 8 weeks, the pigs consumed 32, 1 and 22% more of flavors 102, 103 and 104. These results indicate that the pigs' preference for flavors change with age, and that baby pigs do have preferences for certain artificial flavor combinations while they tend to reject others.

74. TIME LAPSE CINEMATOGRAPHY AS A METHOD OF STUDYING ANIMAL BEHAVIOR AND RATION PREFERENCES. L. A. Facto, F. Diaz, V. W. Hays and D. V. Catron, *Iowa State University of Science and Technology.*

A technique utilizing a 16 mm. motion picture camera which had been modified to take single frame pictures at a frame rate of one every 12 seconds was used cinemagraphically to record the behavioral activities for 3½ days of eight pigs divided into two pens in conjunction with taste preference studies. The feeders were alternated within pens at 24-hr. intervals. The purpose was to ascertain any peculiarities or uniformities regarding individual differences or group dynamics pertaining to the pig's behavior regarding feed preference. Information from the processed film was transcribed to a long sheet of graph paper to allow the determination and measurement of selected factors. By using the cinemagraphic technique it was possible to relate facts possibly relevant to the study which were not predicted from routine records. These were: 1. Pigs are oriented to a 24-hr. day, i.e., they sleep more at night than in the daytime, even though artificial light intensity was constant. 2. Their feeding, drinking, and sleeping follow a set rhythmical pattern which in some way appears to be group oriented and in other ways that suggest individual peculiarities. 3. A general restlessness exists when attendants are present. It is obvious at this point that the pigs were space oriented regarding the feeders, in that they preferred the one nearer the water fountain regardless of what diet it contained. If taste preferences do exist in young pigs, frequently alternating the feeders' location hides the possibility of establishing this fact.

75. THE EFFECT OF LEVEL OF FEED INTAKE OF MATURE BOARS ON FERTILITY AND ON CERTAIN CHEMICAL CONSTITUENTS OF THE EJACULATE. Emmett Stevermer, Martin F. Kovacs, Jr., W. G. Hoekstra and H. L. Self, *University of Wisconsin.*

Six Yorkshire boars, 22 months of age and of known fertility, were divided into three groups. Group I was self-fed and consumed an average of 13.6 lb. per head per day. Groups II and III were hand fed 6¾ and 4½ lb. per day, respectively, of the same ration as Lot I. The boars were penned individually and collected twice weekly over a 24-week period. The average change in weight during the period in Groups I, II, and III was plus 298, plus 77, and minus 33 lb., respectively. The average volume of the strained ejaculate was 245 ml. and ranged from 92 to 434 ml. The mean volume was 285, 249, and 200 ml. for groups I, II, and III and the total number of sperm per ejaculate was 62.7, 42.3, and 53.6 billion, respectively. The concentration of citric acid, fructose, total nitrogen, nonprotein nitrogen and protein nitrogen ranged from 55 to 335, 0.5 to 114, 153 to 680, 20.6 to 51.5 and 123 to 635 mg. per 100 ml. of strained semen, respectively. All values were significantly ($P<0.02$) decreased in Group III. No significant increases were observed in Group I. The total amount of citric acid and fructose per ejaculate ranged from 52 to 1024 and 0.5 to 449 mg., respectively, and

was significantly ($P<0.05$) lowered in Group III. The concentration of ergothioneine ranged from 15 to 84 mg. per 100 ml. and the total per ejaculate from 16 to 252 mg. The total secretion of ergothioneine was highly correlated with the average daily feed consumption ($P<0.01$). There was no difference in conception rates at the start of the experiment. At the end of six months, the conception rates in Groups I, II, and III were 68.8, 50.0 and 31.2%, respectively.

76. THE INFLUENCE OF HAND-FEEDING, SELF-FEEDING, AND FREQUENT-INTERVAL FEEDING ON PERFORMANCE AND BEHAVIOR OF BEEF CATTLE. R. K. Mohrman, W. W. Albert, A. L. Neumann, and G. E. Mitchell, Jr., *University of Illinois.*

Three trials were conducted in this study. In trial 1, nine Hereford cattle were hand-fed two times daily and eight cattle were fed automatically by machine six times daily at 4-hour intervals. The cattle received only the amount of feed that they would clean up in a reasonable time after each feeding, no attempt being made to equalize feeding. Percentage composition of the ration was corn, 55; ground cobs, 33.5; soybean meal, 10; and, alfalfa meal, 1.5. The cattle fed six times daily consumed 3.4 lb. or 17% more feed per head daily and were slightly more efficient in feed conversion than those fed two times daily. The lot fed six times gained faster ($P<0.05$) than the lot fed two times daily (ADG 1.87 vs. 1.55). In trial 2, six Hereford steers were used in a reversal type digestion trial, to study the effect of frequent feeding (four times vs. one time daily) on nitrogen and energy digestibility. Frequent feeding significantly increased nitrogen and energy digestibility ($P<0.01$). In trial 3, three lots of 10 yearling steers each were group-fed according to three plans as follows: Lot A was fed six times daily, Lot B was fed two times daily, and Lot C was self-fed. Percentage composition of the ration was ground corn, 64; ground cobs, 25; soybean meal, 10; and alfalfa meal, 1. After 84 days of a 104-day trial, daily gains were 1.95, 1.75, and 1.99 lb. for Lots A, B, and C, respectively, while daily feed consumption was 19.5, 18.6, and 21.1 lb. Feed required per lb. gain was 10.0, 10.6, and 10.7 lb. for Lots A, B, and C respectively.

77. ROLLED COMMON BARLEY SERVES AS BOTH GRAIN AND ROUGHAGE FOR FATTENING STEERS. H. B. Geurin, J. L. Williamson, J. C. Thompson, H. L. Wilcke and R. M. Bethke, *Ralston Purina Company Research Department.*

A series of six experiments has developed a new concept of feeding barley to fattening cattle, the premise being that the past limitation of barley for rapid finishing of cattle has been that the cattle receive roughage from both hay fed and the hull portion of barley. The first three experiments were pilot tests using 21 steers to study the effect of feeding only properly supplemented barley on a full-feed basis starting the first day on test. Barley from different areas of the country was used. The barley was rolled to preserve the roughage characteristic of the hulls and the supplement used was a mixed, fortified 32% protein supplement. The last three experiments were direct comparisons with 82 steers to compare cattle full-fed on rolled barley versus ground ear corn. The initial work shows that barley supplied sufficient roughage for the steers to gain rapidly, to utilize the ration efficiently, and to ruminate normally. Composite results of the last three experiments for corn and barley cattle, respectively, are daily gain, 2.63, 2.95* (*Significantly greater at 1% level); feed per cwt. gain, 865, 708* (*Significantly less at 1% level); shipping shrink, 3.48, 3.63; selling price, $26.94, $27.30; chilled dressing percent, 60.20, 60.32; carcass grade, Low Choice, Low Choice. Bloating was never observed in any of the cattle. This work shows that cattle can gain rapidly, finish quickly, and utilize adequately supplemented barley very efficiently as both grain and roughage.

78. THE EFFECT OF FEEDING LAMBS NATURAL VS. SEMI-PURIFIED RATIONS ON THE STOMACH WORM, HAEMONCHUS CONTORTUS. R. L. Vetter, A. L. Pope, A. C. Todd and W. G. Hoekstra, *University of Wisconsin.*

An experiment with 12 heavily parasitized lambs showed that feeding a pelleted semi-purified ration greatly reduced fecal egg count levels when compared with lambs fed a natural ration. When lambs previously fed the semi-purified ration were fed the natural diet, fecal egg counts increased to control values within 2 days. On the other hand, egg counts fell markedly when lambs started on the natural ration were fed the semi-purified. A second experiment was conducted to determine if this pronounced effect was due to physical form of the ration and whether it could be reproduced by feeding a pelleted natural ration. Fifty-six 3- to 4-month-old lambs were allotted by random block design into seven equal groups; three groups were fed a natural ration; two groups received the same ration in pelleted form; and two groups were given a pelleted semi-purified ration. Each lamb was infected with 15,000 viable third-stage larvae. No differences in fecal egg counts, hemoglobin values or weight gains were found between lambs fed the natural and the pelleted natural rations. The lambs fed the semi-purified ration had significantly lower fecal egg counts, but with reduced hemoglobin values compared to the other groups. Inter-exchange of the natural rations with the semi-purified again resulted in a rapid reversal of the fecal egg count levels. In a second reversal, i.e., restoration of original feeding regimen, fecal egg counts of each group returned approximately to the levels observed prior to the first reversal.

79. THE INFLUENCE OF SEVERAL DIETS ON THE BLOOD GLUCOSE LEVELS AND INTRAVENOUS GLUCOSE TOLERANCE OF YOUNG DAIRY CALVES. R. G. Warner, H. N. Harrison and J. K. Loosli, *Cornell University.*

Thirty male Holstein three-day-old calves were divided into three groups and all fed a basal ration of 350 lb. of whole milk during the first 7 weeks. In addition they were allowed either milk (I), grain (II), or hay (III) *ad libitum*. Whole blood glucose was determined weekly. Calves were slaughtered periodically (J. Ag. and Food Chem. 4:788, 1956) so that only four calves per group remained after 10 weeks. Whole blood glucose declined uniformly for the first 5 weeks. Thereafter, the following differences ($P<0.05$) were observed at the respective weeks of age; 7, I>II and III; 10 and 12, I and II>III. Level of blood glucose was not a useful criterion of developing rumen function since, at slaughter, grain calves, though having an elevated blood glucose level, had a normal rumen function as determined by rumen size, structure, and papillary development, and by evidences of an active fermentation. Intravenous glucose tolerances did not differ between diets to 6 weeks of age, but, between 9 and 14 weeks III had a significantly ($P<0.05$) lower tolerance than I and II. The average disappearance of glucose 80 minutes post-injection was less for I than II (not statistically significant). Preliminary evidence suggests that level of feed intake may be of more importance in our results than the type of feed.

80. CALCIUM CARBONATE AND CORN OIL INFLUENCES UPON RATION DIGESTIBILITY IN LAMBS. K. L. Davison and Walter Woods, *Iowa State University.*

A series of digestibility studies with lambs were conducted to determine the effects of corn oil, corn oil saponified with potassium hydroxide, corn oil plus calcium carbonate, and calcium carbonate upon digestibility of a ration composed of ground corn cobs, 46%; ground shelled corn, 32%; corn gluten meal, 20%; salt, 1%; dicalcium phosphate, 1%; and vitamin A and cobalt added. Corn oil or corn oil saponified with potassium hydroxide was found to decrease the digestibility of dry matter, organic matter, protein and cellulose and to increase the digestibility of ether extract. Corn oil decreased the digestibility of ash. Calcium carbonate largely overcame the depress-

ing effects of the corn oil on digestibility and increased the apparent digestibility of the corn oil. Calcium carbonate increased the digestibility of dry matter, organic matter, protein, and cellulose of the basal ration containing no added corn oil. The addition of calcium carbonate tended to increase nitrogen retention in both the basal and basal plus corn oil rations. Calcium carbonate increased total digestible energy in the basal ration and further increased digestible energy in the ration containing corn oil. The evidence suggests that the digestible energy of corn oil *per se* was increased by the calcium carbonate in the ration. Magnesium carbonate was as effective as calcium carbonate in partially alleviating the depressing effects of corn oil upon cellulose digestion *in vitro*.

81. EFFECTS OF A TRANQUILIZER (PERPHENAZINE) ON SHRINKAGE AND FEED LOT ADAPTION OF YEARLING FEEDER STEERS. R. M. Luther, L. B. Embry, F. W. Whetzal and M. A. Hoelscher, *South Dakota State College*.

Three shipments involving 168 feeder steers were used to study the effect of perphenazine in reducing transit shrinkage. The shipments (I, II, III), miles transported, and mg. of tranquilizer injected 17 to 20 hours prior to shipment were (I) 300, 84; (II) 240, 93; and (III) 140, 37.5. Tranquilization was apparent one-half hour after injection at 84 and 93 mg., and the cattle were sluggish at loading 17 to 20 hours later. No tranquility was noted after the 37.5 mg. injection. Tranquilized cattle shrunk more between treatment and loading but slightly less during transit than the control groups. Percent total shrink from treatment to after transit for the control and tranquilized groups was: (I) 6.19, 6.04; (II) 9.85, 11.75; and (III) 7.40, 8.11. The difference in shipment II was significant ($P<0.01$). Total gains 14 days after shipment were not significantly different between the two groups. A feedlot adaptation trial was conducted with 273 feeder steers that had been in transit 8 hours and fasted an additional 12 hours. The cattle were allotted to seven treatments consisting of a control and perphenazine administered intramuscularly (IM) and orally at three levels. Treatments were control, 25 IM, 50 IM, 75 IM, 25 oral, 50 oral and 75 oral respectively Average gains by weigh periods were (1 day) 43.4, 38.8, 42.4, 31.9, 39.7, 41.0, 42.9; (3 days) 58.7, 59.2, 59.7, 56.7, 57.1, 58.2, 60.2; (7 days) 84.1, 78.7, 78.5, 76.7, 78.6, 76.6, 80.2; and (14 days) 105.4, 103.0, 108.2, 103.7, 104.4 101.0 111.4 lb. Injected or oral perphenazine regardless of level did not significantly improve gains or feed consumption. Sedation was apparent in the injected lots, particularly the higher levels.

82. THE EFFECT OF PELLETING UPON NUTRITIVE VALUE OF RATIONS FOR PIGS WEANED AT TWO WEEKS OF AGE. A. H. Jenson, D. E. Becker and S. W. Terrill, *University of Illinois*.

Five experiments, involving 224 pigs weaned to dry diets at approximately two weeks of age, were conducted to study effect of pelleting upon ingredient and ration nutritive value. The tests were 4 to 6 weeks in length, and corn-casein, corn-soybean oil meal, and wheat-casein diets were used. Considerable variation existed within and between experiments. However, in four of the five tests, pelleting resulted in more efficient feed utilization. Meal and pellet forms of rations produced comparable gains. Regrinding pelleted rations resulted in a powdery diet not readily accepted by the pigs, with subsequent reduced performance. Comparing meal and pellet form of ration for all experiments, average daily gains (and feed per lb. of gain) were 0.53 lb. (1.75 lb.) and 0.51 lb. (1.51 lb.), respectively. Comparison of meal rations containing regular ground corn or pelleted-and-reground corn showed gains (and feed per lb. of gain) of 0.61 lb. (1.69 lb.) and 0.60 lb. (1.56 lb.) respectively. Proximate analysis of rations revealed a consistent decrease in crude fiber values after pelleting. Laboratory study indicated the starch in pelleted corn to be more susceptible to malt amylase digestion than starch in regular ground corn.

83. THE EFFECT OF VARIED FEED INTAKE TO 8 WEEKS OF AGE ON GROWTH AND DEVELOPMENT OF PIGS TO 200 POUNDS BODY WEIGHT. D. L. Frape, V. W. Hays, V. C. Speer, J. D. Jones and D. V. Catron, *Iowa State University of Science and Technology.*

An experiment was conducted to study the effect of four levels of feed intake (45, 60, 75 and 90% of full feed) from weaning at 19 days of age until 54 days of age. Full feed was estimated on a body weight basis from previous data. The feed was weighed to the nearest 0.01 lb. and fed 3 times daily. During this period the daily output of the thyroxine was measured in 24 of the pigs and found to be reduced significantly only by the lowest feed intake. At 54 days of age those receiving 45% of full feed weighed half as much as those receiving 90% of full feed. From then on the pigs were fed *ad libitum* and slaughtered as each reached 200 lb. when 14 carcass measurements were taken. No significant effects of treatment were found in any of these characteristics. Although 85% of the variation in time to 200 lb. could be attributed to differences in weight at 54 days it required a difference of 2.7 lb. at 54 days to reduce the time to 200 lb. by 1 day. The growth curves were compared to one computed from 697 other pigs fed *ad libitum* to 200 lb. The curve for feed intake on average daily gain was computed for the period up to 54 days and compared to that of 149 pigs individually fed *ad libitum*. Although similar, these curves differed significantly in the position of the Y intercept. Feed efficiencies during the limited feeding were as low as 1.12 lb. feed/lb. gain. An equation for maintenance requirement in the young pig was derived.

84. THE INFLUENCE OF ENERGY—PROTEIN RATIO IN THE RATION ON PERFORMANCE, RATION DIGESTIBILITY AND CARCASS CHARACTERISTICS OF SWINE. A. J. Clawson, T. N. Blumer, F. H. Smith and E. R. Barrick, *North Carolina Agricultural Experiment Station.*

Thirty-six pigs averaging 39 lb. were randomly allotted by littermate groups to a 3 x 3 factorial experiment in which the dietary variables were energy and protein. The rations were formulated to contain constant protein quality and the pigs were individually fed, *ad lib*. Daily gain, feed per lb. gain, av. backfat and area of loin eye for the various fat levels and calorie-protein ratios were: (for 0% added fat) 1.85, 3.41, 1.64, 3.57; (5% added fat) 1.97, 3.11, 1.71, 3.64; (10% added fat) 2.01, 2.88, 1.66, 3.71; (for C/P ratio, 27) 2.00, 3.02, 1.64, 3.71; (C/P ratio, 32) 1.94, 3.14, 1.68, 3.83; (C/P ratio, 41) 1.89, 3.23, 1.69, 3.38, respectively. The C/P ratio represents calories per gram of protein in the rations. Chromium oxide digestibility determinations for dry matter, crude protein, ether extract and N.F.E. were, respectively, as follows: for fat levels (0% fat) 85, 76, 47, 93; (5% fat) 84, 78, 73, 92; (10% fat) 83, 78, 75, 91; and for C/P ratios, (27) 82, 78, 64, 91; (32) 84, 78, 68, 92; (41) 85, 76, 64, 93. Carcass analysis (minus bone and skin) for moisture and ether extract were as follows: for fat levels, (0% fat) 37.1, 52.2; (5% fat) 37.0, 52.2; (10% fat) 35.9, 53.6, and for C/P ratios, (27) 37.8, 51.4; (32) 36.2, 53.3; (41) 36.0, 53.4. Carcass studies irrespective of treatment gave the following correlations: taste value for fatness vs. taste value for juiciness, hams $\gamma = +.48$,* loins $\gamma = -.21$, shoulders $\gamma = .76$,* ether extract vs. taste value for juiciness, hams $\gamma = +.58$,* loins $\gamma = +.36$, shoulders $\gamma = +.24$. Data associating chemical and organoleptic properties with treatments will be presented.

85. THE ENERGY VALUE OF VARIOUS FEEDSTUFFS FOR THE YOUNG PIG. B. G. Diggs, D. E. Becker, S. W. Terrill and A. H. Jensen, *University of Illinois.*

In a series of balance studies the energy value of several feedstuffs for swine was determined as measured by digestible energy, metabolizable energy, and metabolizable

energy adjusted for nitrogen balance. Values were obtained by feeding each test material in addition to a control mixture formulated to provide adequate amounts of all nutrients except energy. Pigs weighing 34 lb. initially were individually fed in metabolism cages for a 6-day collection period. Gross energy and nitrogen determinations on the feed, feces, and urine were made for all pigs. Pigs which received a diet containing approximately 40% protein excreted 6.77 Calories in the urine for each gram of urinary nitrogen. Therefore, this value was used to adjust all metabolizable energy values for nitrogen balance. For all feedstuffs the metabolizable energy averaged 94.7±5.3% of the digestible energy, metabolizable energy adjusted for nitrogen balance averaged 91.6±6.3% of the digestible energy, and metabolizable energy adjusted for nitrogen balance averaged 96.9±1.7% of the unadjusted metabolizable energy. The feedstuff and the adjusted metabolizable energy (Calories per gram) are cornstarch, 3.61: dextrose, 3.26; ground yellow corn, 3.25; ground wheat, 3.08; ground oats, 2.68; rolled oats, 3.47; ground milo, 3.07; wheat bran, 2.18; alfalfa meal, 1.30; corn oil, 7.30; lard, 7.54; stabilized tallow, 7.83; lactose, 3.34; dried whey, 2.93; meat and bone scrap (50%), 1.56; menhaden fish meal, 2.70; tankage (60%), 2.07 and soybean oil meal (50%), 3.39.

86. EFFECT OF HIGH FIBER (CORN COBS) ON RATION DIGESTIBILITY, GROWTH RATE, BACK-FAT, AND FEED EFFICIENCY OF PIGS FED TWO LEVELS OF PROTEIN. R. S. Lowrey, W. G. Pond, J. H. Maner, *Cornell University*.

A total of 68 growing pigs were used in two experiments. In the first trial 36 Berkshire and Chester White pigs averaging 50.5 lb. were allotted to six treatments in which the variables were energy and protein. The animals were allowed rations consisting of corn, cerelose, and protein, mineral, and vitamin supplements *ad libitum* on concrete for 44 days. The av. da. gain (lb.) and feed per lb. of gain (lb.) were as follows: Lot 1 (0% corn cobs-10% protein), 1.56, 3.36; Lot 2 (0% C.C.-18% P.), 1.57, 3.28; Lot 3 (12.4% C.C.-10% P.), 1.36, 3.98; Lot 4 (12.4% C.C.-18% P.), 1.43, 3.57; Lot 5 (24.8% C.C.-10% P.), 1.03, 5.42; Lot 6 (24.8% C.C.-18% P.), 1.22, 4.08. Differences in weight gain were significant ($P<.05$). In the second trial only treatments 1, 2, 3, and 4 were used. Thirty-two Yorkshire pigs averaging 32.8 lb. were allotted to the four treatments with two lots of four pigs per treatment. The animals were fed to approximately 200 lb. Av. da. gain (lb.), feed per lb. of gain (lb.) and back-fat thickness (in.) were as follows: Lot 1, 1.45, 3.59, 1.35; Lot 2, 1.45, 3.53, 1.43; Lot 3, 1.36, 3.94, 1.25; Lot 4, 1.31, 4.13, 1.19. Differences in weight gain were not significant, while differences in back-fat were highly significant ($P<.01$). Chromium oxide digestibility determinations made on the animals of the second replication during the 10th week of the trial resulted in the following values for percent dry-matter, protein, and crude fiber, respectively: Lot 1, 84.1, 67.6, 42.0; Lot 2, 78.9, 70.7, 38.8; Lot 3, 69.9, 60.7, 17.8; Lot 4, 68.8, 71.7, 22.8. Differences in dry matter, protein, and crude fiber digestibility were highly significant ($P<.01$), significant ($P<.05$), and none significant, respectively.

87. SOME EFFECTS OF DIETARY LEVELS OF ALFALFA MEAL AND PROTEIN, AND OF ANTIBIOTIC SUPPLEMENTATION ON GROWTH, FEED EFFICIENCY AND CARCASS CHARACTERISTICS IN SWINE. J. W. Stevenson, R. J. Davey and R. L. Hiner, *Animal Husbandry Research Division, ARS, Agricultural Research Center*.

Two series of experiments were conducted to study the effect (1) of adding 16 or 28% dehydrated alfalfa meal to the rations of swine weighing 100, 125, or 150 lb. and (2) of a protein level of 14 reduced to 11% at 125 lb. versus one of 18 reduced to 15% on feedlot performance and carcass quality. In experiment I when the alfalfa

meal content of the diet was increased from the basal 4% to 16 or 28% progressive decreases in rate of gain and feed efficiency were obtained (ADG 1.65, 1.55, 1.40 lb. and feed eff. 412, 422, 459 lb. for 4, 16 and 28% alfalfa, respectively) and carcass backfat, bacon thickness, and total fat percent were significantly reduced (backfat 1.64, 1.58, 1.45 inch; bacon thickness 2.46, 2.37, 2.30 inch; total fat % 13.6, 13.3, 12.0 for 4, 16 or 28% alfalfa). The addition of alfalfa at 150 lb. liveweight improved carcass grade and increased carcass length significantly, but produced no other marked effects. In experiment II neither the difference in protein level nor the presence or absence of chlortetracycline caused any significant changes in feedlot results. The high protein level significantly reduced the percentage of carcass fat (15.6 and 14.2% for high and low protein respectively) and increased the percentage of preferred cuts (50.1 and 49.2% for high and low protein). The only significant effect on the carcass produced by chlortetracycline addition was a reduction of backfat in pigs receiving the supplement during the first half of the experiment, 1.64 inch with antibiotic and 1.77 inch without.

88. EFFECTS OF DIETARY ANIMAL FATS ON GROWTH, FEED EFFICIENCY AND CARCASS CHARACTERISTICS OF SWINE. D. M. Thrasher, R. E. Brown, A. M. Mullins, Sam L. Hansard and Paul B. Brown, *Louisiana State University*.

Two similar experiments involving a total of 112 weanling pigs were conducted in winter and summer to study the effects of adding a grease, a tallow, and lard at 5% and 10% levels to a conventional growing-finishing ration. In each trial an additional group was fed a low-energy ration containing 20% oats and no added fat. The rations were isonitrogenous. In Trial I (winter) the addition of the fats to the basal ration produced a highly significant increase in daily gains, but no significant differences among fats. Gains on the 10% level of fat were significantly greater than on the 5% level ($P=.01$). Feed consumption decreased slightly as the level of fat increased. Feed efficiency was improved by 11% and 21% at the 5% and 10% levels, respectively. Backfat thickness and total fat trim tended to increase as the level of fat increased, but differences were not significant. Average iodine numbers of backfat samples were lowest for the pigs fed tallow and highest for those fed lard. The pigs receiving fat consumed more total gross calories per day, but required fewer calories per pound of gain. In Trial II (summer) rations identical to those of Trial I were fed. An increase of approximately 10% in gains was obtained with tallow and lard, but the gains of pigs receiving the grease were slightly reduced. Feed consumption was slightly reduced, and feed efficiency was improved approximately 11%, on the average, when fat was added.

89. EFFECT OF MARGINAL VITAMIN A INTAKE DURING GESTATION IN SWINE. D. P. Heaney, D. E. Ullrey, E. R. Miller and J. A. Hoefer, *Michigan State University*.

Fifteen gilts, after being depleted of vitamin A reserves for 6 months, were divided into three experimental groups. They were then bred and were individually fed throughout gestation. During gestation the three groups were given supplemental vitamin A as follows: group 1, control—16 mcg. vitamin A/kg. liveweight daily; group 2, 5 mcg./kg. liveweight daily and group 3, 2.5 mcg./kg. liveweight daily. After parturition milk samples were obtained at birth, 24 hours, 72 hours and 1 week. Half of each litter was sacrificed at birth to obtain livers. The three groups produced 3 litters, 5 litters and 4 litters, respectively. The level of supplemental vitamin A during gestation had no effect upon litter size, birth weight, or livability. There were no abnormalities or visible symptoms of vitamin A deficiency in any of the three groups. Milk vitamin

A levels, at each of the four intervals, were considerably higher from the control gilts than from gilts in either of the other two groups. There was a tendency for gilts of group 3 to have lower milk vitamin A than gilts of group 2, though these latter differences were slight. Vitamin A storage in the liver of the newborn pigs was found to be substantially affected by the gestation level of vitamin A intake. The average (and ranges) in liver storage for the three groups were 10.4 (5.5 to 20.8) mcg. vitamin A/gm. liver, 2.4 (0.6 to 10.6) and 0.8 (0.4 to 1.4), respectively.

90. SOME EFFECTS OF ESTROGENIC, ANDROGENIC AND TRANQUILIZER COMPOUNDS ON PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING-FINISHING SWINE. D. M. Baird and H. C. McCampbell, *Georgia Experiment Station.*

Three feeding and slaughter tests were conducted with some estrogenic, androgenic and tranquilizer compounds in conjunction with high energy diets for swine from weaning to 200 lb. Purebred Poland Chinas were allotted on a basis of weight, sex, sire and litters into lots of eight animals each. Treatments, ADG and feed per cwt. gain for the first test were (1) Basal 1.58, 354; (2) 1 + 8% tallow 1.73, 308; (3) 1 + 3 mg. stilbestrol implant 1.83, 354; and (4) 3 + 0.25 mg. hydroxyzine per lb. feed daily 1.76, 316. No significant treatment differences occurred in performance and carcass characteristics. Significant sex x treatment interaction resulted for ADG, dressing percent, back fat, length, loin marbling and fat hardness. Treatments, ADG and feed per cwt. gain for the second test were (1) Basal 1.26, 348; (2) 1 + 8% tallow 1.13, 340; (3) 1 + 3 mg. stilbestrol implant 1.33, 357; (4) 1 + 2 + 3, 1.35, 319; (5) 1 + 2 + 0.25 mg. hydroxyzine per lb. feed daily 1.20, 352 and (6) 1 + 2 + 5 1.50, 294. Gains were not significantly different. Lot 4 had significantly greater back fat depth than lots 2 and 5. Barrows gained significantly faster than gilts and had significantly less loin eye area and marbling. A third test involving androgenic compounds in comparison with stilbestrol and estradiol-progesterone showed no growth differences with carcass characteristics to be reported. Generally, estrogens, androgens and tranquilizer compounds have failed to improve performance or alter carcass characteristics of drylot fed swine from weaning to 200 lb.

91. EFFECTS OF STILBESTROL AND A COMBINATION OF PROGESTERONE AND ESTRADIOL ON GROWING-FATTENING SWINE. B. N. Day, S. E. Zobrisky, L. F. Tribble and J. F. Lasley, *University of Missouri.*

Forty-eight Poland China barrows were assigned to 8 lots of 6 animals each at the beginning of the experiment. Two lots of barrows were designated as controls (Group I) and two lots were subjected to each of the following hormonal treatments: Group II, 6 mg. of stilbestrol; Group III, 166.7 mg. of progesterone and 3.3 mg. of estradiol benzoate; Group IV, 500 mg. of progesterone and 10 mg. of estradiol benzoate. All hormones were administered as a subcutaneous implant in the ear at the start of the trial. Average daily rates of gain (lb.) and feed efficiency values (lb. feed/per 100 lb. gain) were Group I, 1.85 and 423; Group II, 1.77 and 403; Group III, 1.85 and 413; Group IV, 1.74 and 403. Differences among treatment groups in rate and efficiency of gain were not statistically significant. Backfat thickness was significantly reduced by the progesterone-estrogen treatments. Average live probe measurements of backfat thickness for Groups I-IV, respectively, were 1.54, 1.48, 1.40 and 1.36 inches. Carcasses obtained from barrows administered the high level of the progesterone and estrogen preparation had the lowest percentage of fat and the highest yield of lean as indicated by significant differences in the yield of four lean cuts, area of loin eye and dressing percentage.

92. THE "ISOLATION PRINCIPLE" IN SWINE MANAGEMENT. L. J. Sumption and J. S. Collins, *University of Nebraska and University of Minnesota.*

Swine management systems receive relatively little research emphasis; yet, sweeping recommendations based on insufficient experimental evidence are frequently made. Relative efficiency of various confinement and pasture systems remain to be adequately tested. Nutritional and climatic aspects are emphasized (often without temperature data) although other environmental factors may have a major influence on results especially when interpreted in relation to Notre Dame's germ-free life studies. It is proposed that new thought be given to the sow and litter as the basic biological unit in management plans and allow for a greater degree of isolation particularly before weaning. In a preliminary study progeny of 36 litters were farrowed in September and reared in two environments, a central farrowing house and pasture lots for individual litters. After weaning, pigs were allotted by weight and breeding group within environmental treatment. Rate of gain, backfat, feed efficiency and temperature variations were recorded. Most pre-weaning and post-weaning results favored pasture management; mortality was lower, weaning weights, and post-weaning gains were higher but feed per lb. of gain was also higher. Environment had no consistent effect on backfat thickness. Mortality data and growth variations of barn-reared pigs suggest the importance of the isolation principle. The results are contrary to most similar summer experiments and indicate the conditional nature of the evidence relating to management systems. The rank order of a series of systems may vary depending upon which environmental factors are most limiting at a particular time.

93. EFFECT OF ASCARIDS ON THE NUTRITION OF THE PIG. K. W. Scott and P. R. Noland, *University of Arkansas.*

Copper sulfate, Hygromycin B, Nicarbazin, and Glycamide were tested for their antilarval activity when incorporated in the rations of pigs receiving large oral doses of embryonated ascarid ova. In trial 1, the treatments were used with both a normal protein level (18%, Lots 1 through 6) and a low protein level (12%, Lots 6 through 12). All pigs except controls (Lots 1 and 7) were administered 1,320,000 embryonated ascarid ova over an 11-day period. Lots, treatments, average daily gains, and feed efficiencies are as follows: Lot *1,* Control, 0.99, 2.98. Lot *2,* Infected, 0.87, 3.25. Lot *3,* (Nicarbazin, 0.02%), 0.99, 3.24. Lot *4,* Copper (200 ppm.) as $CuSO_4$, 0.95, 2.64. Lot *5,* Glycamide (0.04%), 0.89, 2.95. Lot *6,* Hygromycin B (5# per ton), 0.92, 2.32. Lot *7,* Control, 0.19, 8.13. Lot *8,* Infected, 0.31, 4.80. Lot *9,* Nicarbazin (0.02%), 0.39, 3.81. Lot *10,* Copper 0.17, 8.44. Lot *11,* Glycamide, 0.30, 5.29. Lot *12,* Hygromycin, 0.33, 5.05. Trial 2, was designed to test the effectiveness of these substances under field conditions. Lots, treatments, average daily gains and feed efficiencies are as follows: Lot *1,* Control, 1.32, 4.72. Lot *2,* Infected, 1.14, 4.36. Lot *3,* Nicarbazin (0.02%), 1.18, 4.23. Lot *4,* Copper (200 ppm.), 1.02, 4.18. Lot *5,* Glycamide (0.04%), 0.96, 5.03. Lot *6,* Hygromycin B, (5# per ton), 1.26, 3.90.

94. INFLUENCE OF LEVELS OF NUTRITION AND STILBESTROL ON PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING-FINISHING BEEF STEERS. G. W. Dilley, M. B. Wise, E. R. Barrick, T. N. Blumer and E. J. Warwick, *North Carolina Agricultural Experiment Station and U.S.D.A.*

Sixty yearling beef steers were used in a 3 x 2 factorial design employing three levels of nutrition with equal replication at each level. Half the animals on each level were implanted with 24 mg. of stilbestrol. Five steers were fed in each of 12 lots from an initial weight of 675 lb. Full-feed was calculated as 3% of body weight, whereas the 80% and 60% levels of nutrition were calculated as those percentages of full-feed above maintenance. The complete mixed ration was based on ground ear corn. Intake was adjusted at bi-weekly intervals according to body weight. Animals were slaughtered

by nutrition levels when the average gain reached 350 lb. The data revealed the following values for the levels of nutrition, Full-feed (FF), 80% FF and 60% FF, respectively: Days on exp't 126, 154, 182; Daily gain in lb. 2.61, 2.13, 1.90; feed per lb. gain in lb. 9.4, 10.2, 9.9; % separable fat 31.6, 29.4, 28.4, % separable lean 52.2, 53.6, 53.6; % ether extract 3.4, 3.2, 3.1; area of fat in mm. per sq. in. ribeye 24.1, 24.0, 26.8; rind thickness in mm. 15.4, 15.8, 13.1; area of eye muscle in sq. in. 10.5, 10.6, 11.0. Values for zero and 24 mg. levels of stilbestrol were respectively: Daily gain in lb. 2.06, 2.37; lb. feed/lb. gain 10.4, 9.3; % separable fat 31.4, 28.2; % separable lean 51.9, 54.3; area of fat in mm./sq. in. ribeye 25.6, 24.2; rind thickness in mm. 15.8, 13.6. Values from the treatment combinations indicate that higher nutrition levels are necessary for the expression of pronounced stilbestrol effects. The 60% FF level of nutrition produced least separable fat and thinnest rinds but greatest amount of marbling.

95. THE EFFICACY OF DEHYDRATED ALFALFA AND STILBESTROL IN FATTENING BEEF CATTLE RATIONS. J. K. Matsushima and D. C. Clanton, *University of Nebraska.*

Two experimental feeding trials have been conducted to study the value of dehydrated alfalfa pellets with and without stilbestrol. For each trial 80 yearling steers weighing approximately 650 lb. were divided into eight lots. None of the animals had been fed or implanted with stilbestrol or similar material previous to these experiments. The basal ration for each lot consisted of ground shelled corn and prairie hay. Mineral and vitamin A supplementations were made to all of the lots. The variables among the eight lots were four different levels—0, 1.25, 2.5 and 5.0 lb. per head daily of dehydrated alfalfa with and without stilbestrol. One-half lb. and 1 lb. of soybean oil meal constituted a part or all of the protein supplement for the groups that were fed 1.25 lb. and no dehydrated alfalfa, respectively, in the ration. Assays with castrated female mice showed 0.4 to 0.6 mcg. of stilbestrol activity per lb. of dehydrated alfalfa. Steer gains and feed efficiency increased as the level of dehydrated alfalfa in the ration was increased. Without stilbestrol, the daily gains for the average of two trials were 2.07, 2.30, 2.41 and 2.46 lb. for the steers fed 0, 1.25, 2.5 and 5.0 lb. of dehydrated alfalfa, respectively. Where 5 mg. of stilbestrol were added to the ration the daily gains for the corresponding levels of dehydrated alfalfa were 2.47, 2.59, 2.64 and 2.64 lb. The data from these trials indicate that dehydrated alfalfa has estrogenic properties quite similar to those of stilbestrol and may possibly increase the effectiveness of stilbestrol.

96. EFFECTS OF STILBESTROL AND THE DURATION OF FEEDING ON CARCASS COMPOSITION AND FEEDLOT PERFORMANCE OF BEEF STEERS. M. L. Ogilvie, E. C. Faltin, R. W. Bray, E. R. Hauser, W. G. Hoekstra, *University of Wisconsin.*

Two trials, each involving 40 steers were conducted to study the effects of stilbestrol on feedlot performance and certain carcass characteristics. Four steers made up an initial slaughter group each year, the remaining were assigned to three lots each of 12 steers (Lot I, 0 mg.; Lot II, 10 mg.; Lot III, 30 mg. stilbestrol/steer/day). Four steers from each lot were slaughtered and processed after 56, 112, and 168 days on feed. Protein, moisture and fat determinations were made on various wholesale cuts and a composite sample representing the right side of the carcass. Rate of gain was not significantly increased by the 10 mg. level of stilbestrol nor was feed efficiency greatly improved. Lot III (30 mg.) steers made faster gains than the controls during the 0–56 ($P<.01$) and 0–112 ($P<.05$) day stages (3.48 vs. 3.16 and 3.00 vs. 2.66). Lot III steers also made more efficient gains than the controls (TDN/100 lb. gain). Stilbestrol fed steers were lighter in fatty cuts such as the flank and kidney knob and heavier in the rump. Carcasses from Lot III (30 mg.) were significantly higher in percentage of protein

75 mg. Terramycin, gained 2.34 lb. per day or significantly more than control steers or those on any other treatment. In the second experiment replicated lots of steers implanted with 36 mg. diethylstilbestrol were fed tranquilizers as follows: Hydroxyzine, 2.5 mg.; reserpine, 1.0 mg.; reserpine, 2.0 mg.; trifluomeprazine, 2.5 mg. and trifluomeprazine, 5.0 mg. Daily gains ranged from 2.24 lb. to 2.47 lb. per day but there was no significant difference in gain between lots. Cattle in the third experiment were fed 75 mg. of Terramycin per day and the treatments were hydroxyzine, 2.5 mg.; reserpine, 1.0 mg.; reserpine, 2.0 mg.; trifluomeprazine, 5.0 mg.; and trifluomeprazine, 10.0 mg. Daily gains ranged from 2.40 lb. to 2.63 lb. per day but there was no significant difference in gain between treatments.

102. SOME METABOLIC EFFECTS OF VARYING LEVELS OF HYDROXYZINE WHEN FED TO BEEF CATTLE. A. T. Ralston and I. A. Dyer, *State College of Washington.*

Twenty-eight yearling Hereford steers were fed either 0, 2.5, 12.5, 62.5 or 312.5 mg. of hydroxyzine per head daily. Increased gains of 0.25 lb. daily from 2.5 and 12.5 mg. treatment with a reduction of 0.25 lb. resulting from the 312.5 mg. level occurred. Differences ($P<.10$) in efficiency of energy retention were found ($0<2.5$, $12.5, 62.5<312.5$). Treatment significantly ($P<.01$) affected fecal ether extract but had no effect upon urinary loss measured by urinary glucose and total urinary loss. Nitrogen retention was not affected by treatment. Blood glucose followed the trend established by blood epinepherine but is significant at a much lower level. Levels of 125 times the recommended 2.5 mg. failed to give noticeable sedation or side effects except for a reduction in appetite.

103. EFFECT OF AUREOMYCIN ON NITRATE POISONING IN RUMINANTS. R. J. Emerick, L. B. Embry, E. W. Whitehead and O. E. Olson, *South Dakota Agricultural Experiment Station.*

Studies with the artificial rumen technique showed that several antibiotics, including Aureomycin at levels of 1 p.p.m. and less, tended to inhibit the reduction of $NaNO_3$ and thus lower, if not completely prevent, the accumulation of $NO_2$ nitrogen. The effect of Aureomycin on methemoglobin (MHb) formation in both cattle and sheep was studied. Seven cattle were schematically rotated among four groups which were fed the following rations: (1) basal; (2) basal + 2% $NaNO_3$; (3) basal + 10 mg. Aureomycin per lb.; (4) basal + 2% $NaNO_3$ + 10 mg. Aureomycin per lb. The animals remained in their respective groups for 2 weeks and were allowed 2-week rest periods between rotations. While receiving 2% $NaNO_3$, the cattle had MHb values of 1.7–23.5% with a median value of 11.9%. When Aureomycin was included in this ration the values were 1.6–19.6% with a median value of 5.6%. MHb values of the remaining two groups were negligible. Eight sheep in each of four groups were fed rations similar to those used for the cattle. In this case, however, $NaNO_3$ was added as 3% of the ration. Average MHb values for the nitrate group reached a peak of 23% in 1 week. A peak for the nitrate plus Aureomycin group appeared to be delayed and did not occur until the sheep had been on the experimental regime 4 weeks. The peaks, when reached, were of similar magnitude for these two groups. In these studies Aureomycin appeared to be effective only in delaying and not in preventing, the methomoglobinemia of nitrate poisoning.

104. SUSTAINED PREVENTION OF BLOAT BY ANTIBIOTICS IN ROTATION OR IN COMBINATION. R. H. Johnson, P. A. Hartman, L. R. Brown, H. H. Van Horn and N. L. Jacobson, *Iowa State University.*

Forty cattle (including six with rumen fistulas used for bacteriological studies and antibiotic assays) were divided into three groups of approximately equal bloating

potential and allowed to graze alfalfa twice daily. The experimental design and procedures were reported previously (J. Animal Sci., 17:1219, 1958). Incidence of serious bloat was high. Individual antibiotics fed in succession to one group had the following effects: 140 mg. spontin (S) per animal daily, no effect; 210 mg. S, some protection; 70 mg. novobiocin (N), reduced bloat 5 days; 35 mg. procaine penicillin (P), prevented bloat 9 days plus 2 more days when P was increased to 70 mg.; 70 mg. erythromycin (E), prevented bloat approximately 10 days after which repeating P had little effect; 70 or 140 mg. oxytetracycline or 35 or 70 mg. neomycin, slight effect; 70 mg. chloramphenicol (C), slight effect; 140 mg. C, reduced bloat; 70 mg. tylosin (T), reduced bloat; 105 mg. T, prevented bloat. A second group received antibiotics in combination (combiotics); 35 mg. P + 70 mg. E daily (with S for the first 8 days and N during the next 10 days) prevented bloat for 26 days, probably due to the P + E. Control and combiotic-treated groups were reversed and 70 mg. P + 70 mg. E prevented bloat for 23 days. Combiotics provided some protection after the 26- and 23-day periods but the effect was declining. Combiotics prevented bloat more effectively than did antibiotics fed in rotation, although rotation may be more effective in sustaining prevention if a sufficient number of effective antibiotics are used. Serious cases of bloat were relieved routinely with a vegetable-oil product developed for that purpose.

105. EFFECT OF DIETARY TERAPHTHALIC ACID ON LAMBS FED OXYTETRACYCLINE AND CHLORTETRACYCLINE. Joe D. Robbins and H. O. Kunkel, *Texas Agricultural Experiment Station.*

Teraphthalic acid was included in the diet of fattening lambs at 0.3% in an attempt to evaluate its potentiating ability on oxytetracycline and the resulting effect on the development of urolithiasis. Two hundred and thirty-two wether lambs divided into 14 lots were fed the following diet for 72 days: 35% cottonseed hulls, 10% cottonseed meal, 40% ground milo, 10% molasses and 5% dehydrated alfalfa leaf meal. Teraphthalic acid did not significantly affect the rate of gain or feed efficiency when fed with 15 mg. oxytetracycline per lb. of feed but resulted in slight reduction of gain when fed with 15 mg. chlortetracycline per lb. of feed. Antibiotic activity was not detectable in blood samples drawn from the lambs 30 days after the beginning of the experiment. No gross symptoms of urolithiasis were observed during the trial. Ten lambs had calculi in their urinary tracts at the time of slaughter. One of the 96 lambs receiving teraphthalic acid had calculi in the urinary tract as compared with 9 of the 122 lambs that did not receive teraphthalic acid. The occurrence of urinary calculi was too limited to evaluate effectively the action of teraphthalic acid on the development of urolithiasis when fed alone or in combination with antibiotics. Teraphthalic acid may be included in the diet of fattening lambs at 0.3% without significantly affecting feed consumption or rate of gain.

106. THE EFFECTS OF FEEDING AN AUTOCLAVED DIET ON THE DEVELOPMENT OF PARAKERATOSIS IN SWINE. I. D. Smith, R. H. Grummer, W. G. Hoekstra and P. H. Phillips, *University of Wisconsin.*

Ninety-eight weanling pigs were used in five experiments to compare the effects of feeding an autoclaved (heated at 230° F. for 1 hour) ration (Lot 1) with a basal ration supplemented with 100 ppm Zn (Lot 2) and an untreated basal ration (Lot 3). A corn-soybean oil meal diet was used. By analyses it contained 1.3% Ca, 0.65% P, 33 ppm Zn and had a calculated protein level of 14%. The first three experiments lasted from 12 to 16 weeks each. Pigs in Lot 1 showed an average increase of 75% in average daily gains over the pigs in Lot 3, and the severity and incidence of parakeratotic skin lesions were markedly reduced. For the fourth study pigs suffering from severe parakeratosis were given the experimental diets. Pigs in Lot 1 showed almost as

rapid a recovery as the pigs in Lot 2 while the untreated controls (Lot 3) essentially showed no change. The average daily gains after 8 weeks for these groups were as follows: Lot 1, 1.56 lb.; Lot 2, 1.77 lb., and Lot 3, 0.70 lb. In the fifth experiment a zinc balance trial was conducted. Eight pigs were used, four receiving the autoclaved ration and four the untreated ration. Measurements were made during the second week. Total food and zinc intake and average daily gains were the same for both groups, while the pigs receiving the autoclaved diet retained more total zinc and had a lower concentration of zinc per unit of feces.

107. THE EFFECT OF COPPER AND CALCIUM LEVELS ON THE PERFORMANCE OF GROWING SWINE. John H. Carter, Jr. Russell F. Miller and C. C. Brooks, *Virginia Agricultural Experiment Station.*

Sixteen weanling Duroc x (Hampshire x Virginia Black) pigs of both sexes were divided equally into four lots and fed the following diets: (1) basal (3 p.p.m. Cu, 0.6% Ca, 0.4% P); (2) basal + 0.65% Ca; (3) basal + 12 p.p.m. Cu; (4) and basal + 12 p.p.m. Cu + 0.65% Ca. The basal diet consisted of degerminated white corn meal, casein, red-dog flour, and a vitamin-mineral supplement. The pigs were fed their respective diets from weaning (25 lb.) to slaughter (195 lb.). Growth was followed by weekly weighings. Average daily gains were 1.39, 1.27, 1.44 and 1.28 for lots 1, 2, 3, and 4, respectively. The addition of calcium to the diets depressed gains (lots 2 and 4). The simultaneous addition of copper with calcium did not overcome this depression. Hemoglobin determinations, 14 weeks after the beginning of the trial yielded values of 10.3, 9.6, 12.2 and 10.3 and at slaughter 13.8, 13.8, 14.8 and 12.2 gm. of hemoglobin per 100 ml. of whole blood for lots 1, 2, 3, and 4, respectively. The hemoglobin content of the blood at slaughter did not express the differences noted at the 14 wk. determinations. Bowing of the front and rear legs was prevalent in pigs fed diets which had not been supplemented with copper. Pigs became unusually weak in the pasterns. Some animals were observed in a sitting or prone position and walked only when forced to do so. Growths appeared on the legs of animals not receiving copper supplements. A limited number of liver cytochrome C oxidase activity measurements indicated a decreased activity in the pigs fed diets without added copper.

108. THE EFFECT OF DIETARY CALCIUM AND COPPER LEVEL UPON THE Cu Fe, Zn, Mn AND Mo CONCENTRATION OF CERTAIN ORGANS AND TISSUES OF SWINE. Russell F. Miller, N. O. Price, John H. Carter, Jr., and C. C. Brooks, *Virginia Agricultural Experiment Station.*

Details of this experiment have been described in another abstract (Carter *et al.*). Blood copper analyses were made periodically and at slaughter. At slaughter, liver, kidney, muscle and rib samples were obtained for analysis. Copper, iron, zinc, manganese and molybdenum were determined chemically by A.O.A.C. methods where available. The results indicated no significant effect of added dietary calcium upon the blood, muscle or rib copper concentration. When compared to the livers of pigs fed the basal diet, the addition of calcium decreased, although not significantly, the liver copper, iron, manganese, zinc, and molybdenum concentration. The addition of calcium to the basal + copper diet resulted in the following concentration changes in the liver: a significant increase in copper, a non-significant increase in zinc and molybdenum and a non-significant decrease in iron and manganese. The addition of calcium to the basal diet resulted in a non-significant decrease in the kidney concentration of copper, iron, zinc, and manganese and a highly significant decrease in molybdenum. Kidney copper and iron concentration in pigs fed the basal + copper + calcium diet was highly significantly decreased, as compared to pigs fed the basal + copper diet. A non-significant decrease in the kidney manganese, zinc, and molybdenum concentration

was observed to result by the addition of calcium to the basal + copper diet. The copper concentration of organs and tissues determined was increased over controls by added dietary copper.

109. EFFECT OF VARIABLE CALCIUM LEVELS WITH AND WITHOUT SUPPLEMENTAL ZINC ON GROWING SWINE. J. A. Hoefer, R. W. Luecke, E. R. Miller, D. E. Ullrey, A. M. Pearson and H. D. Ritchie, *Michigan State University*.

Sixty weanling pigs were divided into six lots, equalized for weight, litter, sex and thriftiness. The basal ration was the same for all lots, and calcium and zinc contents were varied by adding limestone and zinc carbonate. The following treatments were used: (1) 0.3% Ca, (2) 0.3% Ca plus zinc, (3) 0.5% Ca, (4) 0.5% Ca plus zinc, (5) 0.7% Ca, and (6) 0.7% Ca plus zinc. Supplemental zinc was added at the rate of 60 ppm. Rib bones for ash and breaking strength were obtained from all the pigs receiving 0.3% Ca and from five pigs from each of the other treatments. For a 112-day feeding period the daily gains for the six treatments were 1.23, 1.48, 0.89, 1.46, 0.73, and 1.24, respectively. Parakeratosis occurred in all lots not receiving supplemental zinc. The dermatosis ranged from a 40% incidence with mild skin lesions on the 0.3% Ca level to a 90% incidence and very severe lesions at the 0.7% Ca level. No parakeratosis developed in pigs receiving supplemental zinc. Zinc supplementation improved performance at all Ca levels; however, in each case pig performance on the lower Ca level was superior to the next higher one.

110. MEASUREMENT OF PHOSPHORUS UTILIZATION BY SWINE BY AN ISOTOPE TECHNIQUE. L. R. Arrington, C. B. Ammerman, George K. Davis, *Florida Agricultural Experiment Station*.

Weanling pigs were given a single oral dose of one of four inorganic phosphates which had been irradiated for one week at the Oak Ridge National Laboratory to convert a portion of the P-31 to P-32. During a preliminary period and an 8-day experimental period, the pigs were fed a constant amount of a practical ration containing adequate amounts of calcium and phosphorus. Fecal collections for dry matter determination were made at 12-hour intervals for 48 hours before dosing. After administration of the labeled phosphate, total urine and feces were collected at 12-hour intervals for 72 hours and at 24-hour intervals for an additional 72 hours. Excretion of the radioactivity in the urine reached a peak in most animals within the first 12 hours; however, in some pigs this was not reached until 24 to 36 hours. The peak of urinary excretion always preceded that of fecal excretion by at least 12 hours and in some animals by as much as 36 hours. In most pigs, essentially all of the radioactive phosphorus was excreted by 72 hours after dosing. Phosphorus "absorption" values in percent of dose for the four phosphates were chloroapatite, 44.5; dicalcium phosphate 34.5; soft phosphate, 22.4; and, natural iron-aluminum phosphate, 7.3. Accumulated percentages of the dose in urine and in the femur at 144 hours were chloroapatite, 13.5, 0.6; dicalcium phosphate, 4.0, 0.54; soft phosphate, 7.5, 0.42; and, iron-aluminum phosphate, 0.52, 0.02. Variations in the excretion of phosphorus were observed and may be explained in part by the irregularity of the dry matter excretion.

111. TRACE MINERALS, ALFALFA MEAL, DISTILLERS SOLUBLES, FISH SOLUBLES AND MEAT SCRAP ADDITIONS TO CORN-SOYBEAN MEAL RATIONS FOR GROWING-FINISHING SWINE. J. H. Conrad, M. P. Plumlee and W. M. Beeson, *Purdue University*.

A control ration containing 16% protein and consisting of ground corn, 78.8; 50% soybean meal, 18.5; dicalcium phosphate, 1.0; ground limestone, 0.9; iodized salt, 0.5;

vitamin and antibiotic premix, 0.3, was fed to 132 pigs in two growing-finishing experiments from weaning to 100 lb. From 100 lb. to 200 lb. the ration contained 13% protein. All pigs were on concrete from birth to market and in experiment 1 glass-lined watering troughs were used. In experiment 1, the treatments, trace minerals added in p.p.m., daily gain and feed/100 lb. gain, respectively, after 72 days on experiment were (1) control, 1.46 and 278; (2) Zn 50, 1.54 and 265; (3) Lot 2 + Cu 5, Fe 50, 1.55 and 276; (4) Lot 3 + Mn 20, 1.60 and 271; (5) Lot 4 + Mg 200, 1.55 and 272; (6) Co 1.3, Cu 3.6, I 1.9, Fe 48, Mn 61, Zn 50, 1.61 and 278. Pigs in lots 4 and 6 gained significantly faster than those fed the control ration (Lot 1). In experiment 2, the ration containing the trace mineral mixture as added to Lot 6 above (Co, Cu, Fe, I, Mn and Zn) was used as the control and the addition of 2% levels of dehydrated alfalfa meal, corn distillers dried solubles, condensed menhaden fish solubles, meat and bone scraps alone or in combination failed to increase gains or improve feed efficiency of growing-finishing swine. There were no statistically significant differences between treatments in experiment 2.

112. THE BLOOD INORGANIC PHOSPHORUS LEVEL OF THE PIG AS INFLUENCED BY DIETARY PHOSPHORUS AND DIURNAL VARIATION. W. A. Dudley, D. E. Becker, H. W. Norton, A. H. Jensen and S. W. Terrill, *University of Illinois.*

An experiment was conducted to determine the effect of level of dietary phosphorus, source of dietary phosphorus and sampling time on the blood inorganic phosphorus level of the weanling pig. The experiment was divided into two phases separated by a week recovery period. Each phase consisted of a week depletion period followed by a week repletion period. All pigs were individually fed daily at 8 a.m. and 4 p.m. with feed consumption equalized within outcome groups. The basal diet contained 0.1% phosphorus, 0.8% calcium and 200 I.U. of added vitamin $D_2$ per pound. Blood samples were collected at 7 a.m., 10 a.m. and 4 p.m. on the 1st, 3rd, 5th and 7th day of each repletion period. The four treatments of the first repletion period were four equal increments of phosphorus from 0 to 0.3% supplied by $NaH_2PO_4 \cdot H_2O$. There was a significant nonlinear regression of blood inorganic phosphorus on phosphorus dosage, the increment of response increasing with each increment of dose. The linear regression on dose was 0.60, 1.78 and 1.01 mg. % per 0.1% of phsphorus at 7 a.m., 10 a.m. and 4 p.m., respectively, these values differing significantly ($P<0.01$). The four treatments of the second repletion period were the basal diet and the basal plus 0.3% phosphorus from one of $NaH_2PO_4 \cdot H_2O$, dicalcium phosphate and soft phosphate. There were significant differences among the blood values for the four treatments; the treatments interacted with day and sampling time. The corrected mean blood inorganic phosphorus values, for 7 a.m., 10 a.m. and 4 p.m., respectively were 4.72, 3.47 and 3.61 for the basal; 6.21, 8.17 and 6.59 for $NaH_2PO_4 \cdot H_2O$; 6.72, 5.80 and 6.38 for dicalcium phosphate; and 6.01, 4.99 and 5.26 mg. % for soft phosphate.

113. POTASSIUM REQUIREMENT STUDIES WITH PIGS WEANED AT TWO WEEKS OF AGE. A. H. Jensen, D. E. Becker, and S. W. Terrill, *University of Illinois.*

Eighty two-week-old pigs weaned directly to dry diets were used in two experiments of 35 and 28 days duration. The cerelose-crude casein diet analyzed 0.027% and 0.004% potassium in experiments 1 and 2, respectively. In experiment 1 supplementary levels of potassium, added as $K_2CO_3$, ranged from 0.0 to 0.5% (0.1% increments), and in experiment 2, levels of 0.0 to 0.45% (0.05% increments) were used. Pigs on the control ration gained 0.04 lb. per day and gained 0.11 lb. per pound of feed. When an adequate level (0.3%) of potassium was added, rate of gain was 0.57 lb. and gain per pound of feed was 0.49 lb. Pigs on the control diet evidenced poor appetite, growth and feed efficiency throughout the test periods. These pigs developed rough

hair coats, became emaciated, weak, listless and unsteady on their feet. Electrocardiograms of the deficient pigs showed a distinct perversion of the QRS internal as compared to pigs fed adequate potassium. Autopsy of pigs after 5 or 4 weeks on the deficient diets revealed no gross pathological symptoms. Based on growth rate and feed efficiency, the potassium requirement appeared to be approximately 0.26% of the diet.

114. TECHNIQUES FOR MEASURING THE PHOSPHORUS ADEQUACY OF SWINE RATIONS. J. M. Vandepopuliere, G. E. Combs, H. D. Wallace and M. Koger, *University of Florida.*

Techniques for measuring the phosphorus adequacy of both a semi-synthetic and a practical type swine ration have been investigated with 135 pigs weaned at 2 weeks of age and individually fed for 35 days, or until market weight. Response criteria included growth, bone ash and optical bone density. Bone density was obtained from radiographs made by subjecting the fibula to X-rays prior to and following surgical removal. Results of two trials where phosphorus levels of 0.24, 0.36, 0.48, 0.60, and 0.72% were fed with Ca:P ratios of 1.2:1 and 2:1 showed that bone density and bone ash exhibited a linear response; growth was non-linear and was significantly affected by the Ca:P ratios. Results of a factorial experiment where phosphorus levels of 0.40, 0.44, and 0.48% were fed with Ca:P ratios of 0.9:1, 1.2:1 and 1.5:1 indicate a similar response to the criteria as in the previous trials.

115. CHLORTETRACYCLINE ABSORPTION AND CALCIUM UTILIZATION IN GROWING SWINE AS AFFECTED BY TEREPHTHALIC ACID AND CALCIUM SOURCE. R. G. Eggert, W. T. Akers, and C. N. Huhtanen, *American Cyanamid Company, Pearl River, New York.*

Two experiments were conducted with 45 weanling pigs to study the effect of 0.5% terephthalic acid (TPA) and 0.6% tetrasodium ethylene diamine tetracetate (EDTA) with three different rations on absorption of chlortetracycline. A corn-soy basal ration containing 200 gm. chlortetracycline per ton was used. In ration 2 the ground limestone and dicalcium phosphate were replaced with $CaSO_4 \cdot 2H_2O$ and $H_3PO_4$, and in ration 3 all supplemental sources of calcium and phosphorous were omitted. Serum chlortetracycline determinations made after 7 days on feed showed (1) an 80% increase over basal due to removal of all supplemental calcium and phosphorous, (2) a 70% increase over basal when $CaSO_4$ and $H_3PO_4$ replaced ground limestone and dicalcium phosphate, (3) a 50% increase due to feeding TPA, and (4) a 30% increase with the addition of EDTA to the basal, but no increase with EDTA in rations containing $CaSO_4$ or where supplemental calcium and phosphorous were omitted. In a third experiment 24 young pigs were individually fed rations similar to those previously described, with and without 0.5% TPA for 35 days. There were no significant effects on rate of gain; however, the pigs receiving the rations low in calcium and phosphorous tended to gain slightly less than those on the other rations. The serum chlortetracycline levels were in agreement with the previous two experiments. Ration treatments had no effect on serum calcium levels. Bone ash was significantly lower ($P \leqq 0.01$) for the rations low in total calcium and phosphorous, but there was no difference between the rations containing ground limestone and calcium sulfate as the supplemental calcium source.

116. EFFECT OF COPPER SULFATE AND ANTIBIOTICS ON GROWTH RATE, FEED CONVERSION AND FECAL FLORA OF GROWING PIGS. J. A. Hawbaker, V. C. Speer, J. D. Jones, V. W. Hays, and D. V. Catron, *Iowa State University of Science and Technology.*

Four experiments involving 378 pigs were conducted to study the effect of copper sulfate and antibiotics on pig gains, feed conversion and fecal flora. In the first

experiment four levels (0, 0.05, 0.10 and 0.15%) of copper sulfate ($CuSO_4 \cdot 5H_2O$) were tested. The average daily gain and feed per pound of gain was 1.32, 2.79; 1.35, 2.75; 1.44, 2.66; and 1.38, 2.68, respectively, for the four levels. The second experiment was designed to determine if the copper radical or the sulfate radical was responsible for the improvement in gain and feed per pound of gain. The response from the three treatments (basal, sodium sulfate and copper chloride) was 1.13, 2.74; 1.03, 2.89; and 1.40, 2.54, respectively, for gain and feed per pound of gain. In a third experiment copper sulfate (0.1%) was combined with each of four antifungal antibiotics nystatin, phytoactin, phytostreptin and rimocidin. The addition of any of these antifungal antibiotics failed to improve pig performance over diets supplemented with only copper sulfate. The fourth experiment compared copper sulfate (0.1%) and two antibiotics, oleandomycin (5 mg./lb.) and oxytetracycline (25 mg./lb.) in an incomplete factorial. Copper sulfate improved gain equally as well as either of the antibiotics. The combination of copper sulfate with either of the antibiotics resulted in an additive effect on rate of gain. The effects of these treatments were reflected in significant changes in fecal flora patterns.

117. EFFECT OF FEEDING TRANQUILIZERS TO GROWING AND FINISHING SWINE. R. A. Pickett, J. H. Conrad and W. M. Beeson, *Purdue University*.

Two experiments using a total of 132 weanling Duroc pigs were conducted to investigate the effects of feeding tranquilizers to growing and finishing swine. In experiment I, reserpine (Lot 2), Rauwolfia vomitoria (Lot 3), meprobamate (Lot 4), hydroxyzine (Lot 5) and perphenazine (Lot 6) were added to a complete mixed ration at levels of 60 mcg., 25, 25, 0.5 and 0.5 mg. per lb., respectively. This trial was conducted on alfalfa-ladino clover pasture. Average daily gains for Lots 1–6 were 1.61, 1.51, 1.66, 1.55, 1.57, and 1.64 lb., respectively. None of the gains were significantly different from the control lot, and there was little difference in feed efficiency. These levels of tranquilizers did not noticeably affect the behavior or performance of the pigs. Experiment II was conducted in drylot and tranquilizer levels were varied according to each lot's response per 14-day period. Treatments were Lot 1, Control; Lot 2, 0.1–0.5 mg. reserpine per lb. ration; Lot 3, 0.5–2.0 mg. trifluomeprazine; Lot 4, 1.0–5.0 mg. perphenazine; Lot 5, 1.0–5.0 mg. hydroxyzine; and Lot 6, 5–20 mg. tetrahydrozoline. Average daily gains were 1.68, 1.62, 1.54, 1.58, 1.71 and 1.57 lb. for Lots 1 through 6, respectively. Pigs in Lots 3, 4 and 6 gained significantly less ($P<.01$) than those in Lots 1 or 5. The higher levels of trifluomeprazine and perphenazine caused noticeable reduction in the activity of the pigs with reduced feed intake occurring at these levels. Feed intake was reduced considerably at the 20 mg. level of tetrahydrozoline. Rate of gain seemed to be directly dependent on feed intake and the feed required per lb. of gain varied only from 3.26 to 3.38 lb.

118. DEHYDRATED AND PELLETED SILAGES—NUTRITIVE VALUE. W. Brady Anthony, Paul F. Parks, J. K. Boseck, J. G. Starling and C. A. Brogden, *Alabama Polytechnic Institute*.

Ensiled forages generally possess more digestible energy per unit of dry matter than do field cured hays. However, low daily dry matter intake of silage may limit performance of young cattle. Furthermore, cured feeding stuffs are more easily handled than silages in mechanized cattle feeding operations. A study was conducted to determine if the intake of silage dry matter by cattle was appreciably increased and if silages retained a relatively high digestible energy value when they were dehydrated and pelleted. Tests were conducted using yearling, Hereford steers. Testing of feeding stuffs fed in the form of silages were conducted under practical feedlot conditions. Dehydrated and pelleted silages were fed to animals maintained in individual stalls and later in

metabolism crates. When fed in the form of silage, daily dry matter intakes were 6.74, 6.56 and 5.65 lb. for corn, sorghum, and oats silages, respectively. Comparable daily dry matter intakes for these silages after dehydrating and pelleting were 18.31, 17.67 and 17.58 lb. Digestible Calories per kg. of dry matter were 2753, 2955 and 3020 for dehydrated and pelleted corn, sorghum, and oats silage, respectively. For comparative purpose, under the same test conditions, a blended cattle fattening ration and pelleted Coastal Bermudagrass contained 2860 and 1962 digestible Calories per kg., respectively. In the pelleted form, the silages possessed similar nutritive value; when fed as silages, corn silage was superior feed.

119. STEER PERFORMANCE ON AND RUMEN EFFECTS OF DIFFERENT CONCENTRATE: ROUGHAGE RATIOS IN PELLETED AND UNPELLETED MIXED FATTENING RATIONS. D. W. Beardsley, W. C. McCormick, and B. L. Southwell, *Georgia Coastal Plain Experiment Station.*

Feed mixtures with ratios of concentrates to roughages of 70:30, 55:45, and 40:60 were fed either finely ground and pelleted or coarsely ground and unpelleted to fattening steers in drylot for 141 days. A control lot was fed concentrates plus long hay in a rack. The mixtures were made up of ground snapped corn, cottonseed meal, blackstrap molasses, and Coastal Bermuda hay. Average daily gains, daily fed intakes, and feed per lb. gain, respectively, for the seven lots were control, 2.68, 27.8, 10.4; 70:30 unpelleted, 2.97, 26.3, 8.9; 70:30 pelleted, 2.60, 22.1, 8.5; 55:45 unpelleted, 2.70, 27.3, 10.1; 55:45 pelleted, 2.68, 24.3, 9.1; 40:60 unpelleted, 2.46, 10.6; 40:60 pelleted, 2.80, 26.1, 9.3. Gains of steers on unpelleted rations decreased, and on pelleted rations increased, as the proportion of roughage was increased. Steers on the finely ground pelleted feed ruminated only occasionally or not at all. Examination at slaughter revealed a high incidence of dark-colored rumens in steers on high roughage pelleted rations with some incidence in the other lots on pelleted rations. A histological study of rumen tissue samples revealed marked tissue changes, including parakeratosis, in steers on the high concentrate pelleted ration and the control ration but not in steers on a high roughage, unpelleted ration, with variable, but generally mild, changes noted in the other lots. No relationship between the incidence of rumen parakeratosis and dark-colored rumen walls was found.

120. THE EFFECTS OF PELLETED ALFALFA HAY AND DEHYDRATED PELLETED FORAGE-TYPE SORGHUM ON THE WINTER PERFORMANCE OF WEANED HEIFER CALVES. F. W. Boren, E. F. Smith, and B. A. Koch, *Kansas State University.*

Fifty head of choice quality weaned heifer calves were divided into five lots of ten each. The winter ration fed each lot per head daily was as follows: Lot 1—5 lb. alfalfa hay plus forage-type sorghum silage free choice; Lot 2—5 lb. alfalfa hay pellets plus forage-type sorghum silage free choice; Lot 3—5 lb. alfalfa hay plus dehydrated pelleted forage-type sorghum free choice; Lot 4—5 lb. alfalfa hay pellets plus dehydrated pelleted forage-type sorghum free choice; Lot 5—5 lb. alfalfa hay pellets plus dehydrated pelleted forage-type sorghum free choice and 1 lb. prairie hay. Average daily gains in lb. were 1.05, 1.26, 1.34, 1.58, and 1.51, respectively; daily dry matter intake 11.26, 11.45, 15.08, 15.65, and 15.90, respectively. The increased gains made in Lots 2, 3, 4, and 5 over Lot 1, were statistically significant. The percentage increase in average daily gain made by Lots 2, 3, 4, and 5 over Lot 1 was 20, 28, 50, and 43, respectively. The increased average daily gains due to pelleting either alfalfa hay or forage-type sorghum over non-pelleting were significant. Feeding alfalfa hay pellets and forage-type sorghum pellets together produced significantly greater average daily gains than

feeding both but only one of the roughages pelleted. The pelleted alfalfa hay affected the variability of gains between lots 28%, whereas the pelleted forage-type sorghum affected it 52%; therefore, it was more advantageous to dehydrate and pellet the forage-type sorghum than to pellet the alfalfa hay.

121. THE DIGESTIBILITY AND EFFICIENCY OF PELLETED VS. CHOPPED RATIONS FOR GROWING AND FINISHING BEEF CATTLE. D. C. Clanton, W. E. Peden, Jr. and J. Matsushima, *University of Nebraska.*

Each of the following four rations were individually fed to four calves in a growing phase and four yearling steers in a finishing phase: (1) ground concentrate-chopped roughage, (2) pelleted concentrate-chopped roughage, (3) ground concentrate-pelleted roughage and (4) pelleted concentrate-pelleted roughage. Both phases of the experiment were conducted during the winter of 1958–59. The concentrate to roughage ratios were 1 to 3.3 and 2.5 to 1, respectively, for the growing and finishing phase. Because of palatability it was necessary to use a ⅜" screen for the chopped roughage; a ¼" screen was used for the pelleted roughage. The concentrate was finely ground. The digestibility of dry matter, protein and energy was determined by the $Cr_2O_3$ method. The only differences found in the growing rations were that the dry matter and energy in the chopped roughage rations were more digestible than those in the pelleted roughage rations. Gains and feed efficiency were similar. In the finishing rations the dry matter, protein and energy in the chopped roughage were more digestible than in the pelleted roughage and less digestible in the ground concentrate than in the pelleted concentrate. Digestion coefficients were lower for the ground concentrate-pelleted roughage ration. This ration produced the smallest gains and lowest feed efficiency. There were no differences between the other rations. Pelleting did not change the nutritive value of the ration for growing calves. With finishing steers there was an undesirable effect due to pelleting the roughage and a desirable effect due to pelleting the concentrate.

122. PELLETED VERSUS MEAL TYPES OF CREEP FEED FOR SUCKLING LAMBS. R. M. Jordan, H. E. Hanke, Kenneth P. Miller and A. B. Salmela, *University of Minnesota.*

The effect of pelleting creep feeds for suckling lambs was studied in five trials involving 346 lambs. The creep feed contained 5% alfalfa hay, 10% oats, 10% bran, 63.3% corn, 10% soybean oil meal and was fortified with minerals, vitamins and antibiotics. Good quality alfalfa hay was fed free-choice. The ration was finely ground to facilitate pelleting. Half the mixture was pelleted and the balance fed as a fine meal. St. Paul—Creep feed was fed 74 days in self feeders. Feed consumption, rate of gain and feed per lb. of gain, respectively, were pellets, 1.2 lb., 0.73 lb. and 1.62 lb. and meal, 0.66 lb., 0.67 lb. and 0.99 lb. Morris—The lambs were full-fed twice daily. Trial 1, 70 days, lambs fed pellets ate 0.72 lb., gained 0.69 lb. and required 1.05 lb. of pellets per lb. of gain. Lambs fed meal ate 0.75 lb., gained 0.74 lb. and required 1.02 lb. of meal per lb. of gain. Trial 2, 63 days, lambs fed pellets ate 0.55 lb., gained 0.64 lb. and required 0.90 lb. of pellets per lb. of gain. Lambs fed meal ate 0.45 lb., gained 0.66 lb. and required 0.68 lb. of meal per lb. of gain. Grand Rapids—These lambs were self-fed for 74 days. Lambs fed pellets consumed 0.70 lb., gained 0.58 lb. and required 1.2 lb. of pellets per lb. of gain. Lambs fed meal consumed 0.69 lb., gained 0.53 lb. and required 1.30 lb. of meal per lb. of gain. Waseca—These lambs were full-fed daily for 46 days. Lambs fed pellets gained 0.59 lb., ate 0.28 lb. and required 0.47 lb. pellets per lb. of gain. Lambs fed meal gained 0.59 lb., consumed 0.36 lb. and required 0.60 lb. of meal per lb. of gain. Pelleting did not consistently increase gain but was advantageous when self-fed.

123. PELLETED HAY, PELLETED EAR CORN AND A TRANQUILIZER FOR FATTENING BEEF CATTLE. O. E. Kolari, A. L. Harvey, J. C. Meiske, W. J. Aunan and L. E. Hanson, *University of Minnesota.*

Sixty-four 860-lb. grade Hereford steers were divided into four treatment groups of (1) ground ear corn and baled hay, (2) ground ear corn and pelleted hay, (3) pelleted ear corn and baled hay, (4) pelleted ear corn and pelleted hay. Treatment groups consisted of two lots each. One lot in each treatment group was fed 2.5 mg. hydroxyzine (Tran-Q) per head daily. Ear corn was fed to appetite and hay was fed at 4 lb. per head daily. Linseed oil meal was fed at 1.5 lb. per head daily. Corn silage was fed at 15 lb. per head daily for the first 88 days on trial. No corn silage was fed during the last 56 days of the test. Diethylstilbestrol and oxytetracycline were fed at the rate of 10 and 80 mg. per head daily, respectively. The averages for daily gain and feed required (dry matter basis) per 100 lb. gain for the various treatment groups were, in lb., respectively: (1) 1.83, 1107; (2) 2.09, 1005; (3) 1.94, 1024; (4) 1.91, 1005. Hydroxyzine-fed cattle gained 1.90 lb. daily on 1050 lb. feed (dry matter) per 100 lb. gain compared to 1.98 lb. daily gain and 1019 lb. feed (dry matter) for cattle fed no hydroxyzine. Differences in average daily gains of cattle were not statistically significant. A fattening heifer trial is currently in progress with treatments similar to the above steer trial.

124. EFFECT OF PELLETING RATIONS CONTAINING WIDELY VARYING CONCENTRATE-TO-ROUGHAGE RATIOS FOR FATTENING STEERS. J. E. McCroskey, L. S. Pope, D. F. Stephens and George Waller, *Oklahoma Agricultural Experiment Station.*

Two trials were conducted with 48 individually-fed Hereford steers to study the effects of pelleting rations containing 1:4 and 4:1 concentrate : roughage ratios. Each mixture was self-fed in meal or pelleted form. Ground milo, cottonseed meal, and molasses were the concentrates, and chopped alfalfa hay and cottonseed hulls comprised the roughage. Digestible protein, calcium, and phosphorous were equalized in each ration. Data were collected on average daily gain, feed intake, and feed efficiency. A digestibility study was conducted in each trial, chromic oxide being used as an indicator. Cattle in Trial I were slaughtered after 176 days and carcass grade, dressing percent, and composition of the 9–10–11th rib was determined. Greatest gains were obtained on the 1:4 pelleted ration. Rate and efficiency of gain were increased by pelleting the 1:4 ration ($P<.01$); however, gains were decreased by pelleting the 4:1 mixture ($P<.01$). Pelleting resulted in a 14% increase in feed intake on the 1:4 ratio but a decrease of 13% on the 4:1 mixture. Carcass grades favored steers fed the 4:1 meal ration; those of steers on the two pelleted rations were one-third grade lower. Composition of the rib cuts was similar for all treatments. In Trial II, gains at 100 days were greatest on the 4:1 meal ration. Pelleting improved rate and efficiency of gain on the 1:4 mixture, but had no effect on the 4:1 ratio. Results indicate an increase in performance by pelleting high roughage rations but no improvement by pelleting high concentrate rations.

125. ROLLING VS. PELLETING GRAINS, PROTEIN LEVELS AND CERTAIN FEED ADDITIVES IN BEEF CATTLE FATTENING RATIONS. L. S. Pope, Kenneth Urban, and George Waller, *Oklahoma Agricultural Experiment Station.*

Seven feeding trials were conducted involving 197 beef calves and 132 yearlings. All cattle were full-fed milo or barley for approximately 175 days, limited amounts of protein supplement, alfalfa, and sorghum silage. In four comparisons, fine grinding and pelleting milo (3/8 inch cubes) increased gains by 4% and decreased the milo required per 100 lb. gain by 10% over dry-rolled milo. In contrast, feeding steam rolled barley resulted in 10.3% faster gains than finely ground and pelleted barley,

with a slight advantage in feed efficiency. Pelleted grain was less palatable than the rolled product. In four comparisons, increasing the digestible protein content of fattening rations for calves receiving stilbestrol from 9.5% to 11% gave no improvement in gain or carcass merit. Rations for yearling steers containing milo, soybean meal, sorghum silage, and salt (0.23% phosphorous on a dry matter basis) were equal to those containing 0.32% and 0.41% phosphorous. The addition of a complete trace mineral mixture to the above ration gave no improvement in performance, and appeared to depress gains when a urea-milo-bone meal supplement replaced soybean meal. In three comparisons, feeding an antibiotic (erythromycin, 75 mg./head/day) in fattening rations for steer calves gave no improvement in rate of gain or carcass grade and yield. Three tranquilizers were tested: Hydroxyzine (1 to 5 mg./day), chlorpromazine (10 mg./day), and prochloperazine (10 and 50 mg./day). None of the tranquilizers significantly improved feedlot performance or carcass merit.

126. EFFECTS OF TWO LEVELS OF SOYBEAN OIL MIXED INTO A COMPLETE PELLETED STEER RATION ON THE INCIDENCE OF FEEDLOT BLOAT. C. J. Elam and R. E. Davis, *Beef Cattle Research Branch, AHRD., ARS., U.S.D.A.*

A complete pelleted ration was individually fed to 15 steers allowed to eat *ad libitum* and to another 15 steers twice-a-day for 105 days. Composition of the ration was 61% barley, 16% soybean meal, 22% dehydrated alfalfa and 1% salt. Twice-a-day on 3 days each week steers were assigned scores for bloat of from 1 (no bloat) to 5 (death from bloat). Bloat index or average bloat score during this preliminary period was 1.35 for steers fed twice-a-day and 1.21 for *ad lib.* steers—not a significant difference. The two groups of steers were then divided into three subgroups of approximately equal bloating potential and treated as follows: I, basal ration as above; II, basal ration with crude soybean oil replacing 4% barley; and III, basal ration with crude soybean oil at 8% of the ration. During the following 105 days, animals were scored for bloat four times daily and the bloat index values were control, 1.50 (one animal died of bloat); 4% soybean oil, 1.81 (two steers died of uncertain cause); and 8% soybean oil, 2.13. The increase in bloat as a result of feeding the crude soybean oil in the ration was significant ($P<.01$) and the response was linear with increasing levels of oil. During the total 210-day experimental period, feeding steers twice-a-day resulted in a higher ($P<.05$) average bloat index (1.62) than in allowing them to eat *ad libitum* (1.47).

127. EFFECTS OF PELLETING, CONCENTRATE:ROUGHAGE RATIOS AND HEXESTROL IMPLANTS ON FATTENING LAMBS. C. V. Ross and R L. Pavey, *University of Missouri.*

One hundred twelve head of black faced Idaho lambs were group self-fed for 69 days in a 2 x 4 x 4 factorially designed experiment. Wethers were divided into outcome groups and assigned at random to four lots of 12 lambs. Rations fed were as follows: Lot 1, 60% concentrates and 40% roughage fed in meal form; lot 2, 60% concentrates and 40% roughage fed in pelleted form; lot 3, 50% concentrates and 50% roughage fed in pellet form; and lot 4, 40% concentrates and 60% roughage fed in pelleted form. Wethers were subdivided into four uniform groups and implanted with 0, 5, 6, and 7 mg. hexestrol. Ewes were assigned to four lots of 16 and fed the same rations as wethers. Sub-lots were implanted with 0, 7, 8 and 9 mg. hexestrol. Average daily gains and feed required per hundred lb. gain for wethers and ewes combined were as follows: Lot 1—0.54, 757; lot 2—0.55, 755; lot 3—0.62, 711; and lot 4—0.66, 641. Daily gains were significantly higher for lots 3 and 4 than for lots 1 and 2. Grades were significantly higher ($P=.05$) on lambs fed the 60% roughage ration. Lambs on the 60% roughage

ration had significantly lower carcass yields (P=.01) than other lots. Lambs implanted with hexestrol made significantly faster gains (P=.01) than controls. Grades were not affected but carcass yields were slightly reduced.

128. PELLETED COMPLETE RATIONS OF VARYING ROUGHAGE-CONCENTRATE RATIOS FOR STEER CALVES, YEARLINGS AND TWO-YEAR OLD STEERS. R. J. Webb, G. F. Cmarik, G. E. McKibben, H. A. Cate, *University of Illinois.*

Five complete pelleted rations with a concentrate-roughage ratio of 0–100, 15–85, 30–70, 60–40 and 80–20 were self-fed to calves, yearlings and two-year-old steers in the winter of 1958–59 at the Dixon Springs Station. Calves were fed 165 days while the yearlings and two-year-olds were fed 132 days. The concentrate part of the rations consisted of ground shelled corn and soybean meal with ground mixed clover-grass hay or alfalfa hay making up the roughage portion. Daily feed intake varied from 3.29% for the calves on all hay to 2.37% for the calves receiving the 80–20 ratio. Less variation occurred for the yearlings and two-year-olds, being 2.44% and 2.43%, respectively, on the 80–20 ratio; a high of 2.74% for the yearlings on the 30–70 ratio, and 2.87% for the two-year-olds on the all hay ration. Average daily gains of calves varied from 1.74 lb. to 2.39 lb., yearlings 1.71 to 3.33, and two-year-olds 1.64 to 3.33. There were no significant differences between gains made within any age group on the 60–40 and 80–20 ratios. Lot average carcass grades varied from standard to high good in the yearlings and two-year-olds and from low standard to low good in the calves. Again no significant differences existed between the 60–40 and 80–20 ratios.

129. PELLETED RATIONS FOR RUMINANTS AS MEASURED BY DIGESTIBILITY AND FATTENING EXPERIMENTS. Walter Woods and Robert W. Rhodes, *Iowa State University.*

Fattening trials with both steers and lambs were conducted in appraising the value of pelleting the complete ration. In two trials steers that were fed a high corn pelleted ration required less feed per 100 lb. of gain than steers fed conventional unpelleted rations. In one of these trials involving a short feeding period (35 days) the steers fed the pelleted ration outgained the control steers. In the other trial involving a 175-day feeding period gains and carcass evaluations were similar between treatments. In the first lamb trial in which high-corn (55%) fattening rations were fed, liveweight gains were 11% faster with a pelleted ration and with a completely mixed concentrate and chopped roughage ration than with a ration of long hay, shelled corn and supplement fed in a common feed bunk. In a second trial lambs were fed a high-roughage (57–60%) and a low-roughage (36–40%) ration in the same three forms as in trial 1. The results with the high-grain, low-roughage ration were similar to the results obtained in trial 1. The results with the high-roughage ration differed from those with the low-roughage ration in that only pelleting gave superior performance. Liveweight gains were similar between lambs fed the high and low roughage pellets. Feeding either mixed or pelleted rations resulted in increased feed consumption by the lambs. The digestibility of dry matter, organic matter and cellulose was decreased slightly but significantly ($P<0.05$) by pelleting the low and high roughage rations. However, protein digestibility was not affected by the pelleting process, although, the lambs fed the pelleted rations retained more nitrogen.

130. AMINO ACID SUPPLEMENTATION OF PRACTICAL RATIONS FOR SWINE. Edward E. Bartels, Don E. Boenker and L. F. Tribble, *University of Missouri.*

In trial one, 25 weanling pigs were divided into five lots. The lots and treatments were as follows: 1—13% protein, corn-soybean oil meal basal; 2—16% corn-soybean

oil meal; 3—basal + 0.2% lysine, 0.1% methionine and 0.03% tryptophan; 4—basal + 7% fat + 3 amino acids; 5—basal + 10% corn cobs + 3 amino acids. The average daily gains and feed efficiency for the pigs from 40 to 125 lb. for the various lots were as follows: 1—0.99, 406; 2—1.32, 349; 3—1.45, 321; 4—1.51, 290; 5—1.37, 352. The same pigs from 125 to 200 lb. were used in trial 2, lots and treatments being as follows: 1—corn + minerals and vitamins basal; 2—basal + 0.21% lysine, 3—basal + lysine + 0.01% tryptophan; 4—basal + lysine, tryptophan + 0.07% methionine; 5—basal + soybean oil meal. The average daily gains and feed efficiency for the pigs in the various lots were as follows: 1—1.50, 491; 2—1.66, 428; 3—1.68, 436; 4—1.7, 440; 5—2.05, 350. In trial 3, fifteen Hampshire-Duroc crossbred pigs were divided uniformly into three lots. The lots and treatments were as follows: 1—16% protein, corn-soybean oil meal; 2—13% protein, corn-soybean oil meal + 0.2% lysine, 0.1% methionine and 0.03% tryptophan; 3—13% protein, corn-soybean oil meal + 0.2% lysine and 0.1% methionine. The average daily gains and feed efficiency for the pigs in the various lots were as follows: 1—1.77, 269; 2—1.53, 286; 3—1.50, 284.

131. EVALUATION OF LYSINE IN PRACTICAL SWINE RATIONS. N. D. Magruder, W. C. Sherman and W. M. Reynolds, *Chas. Pfizer & Co., Inc., Terre Haute, Indiana.*

Two trials were conducted with baby pigs, each trial utilizing as basal rations conventional starters, containing 14% and 16% protein, with two replicates receiving 0.1% supplemental L-lysine on each protein level. There was a significant difference ($P<0.05$) between protein levels without lysine. All four replicates in the two experiments in which lysine was added to 14% protein surpassed controls, averaging 16% better gains and 4% better feed efficiency at 56 days. With 16% protein, a 10% improvement in gain from lysine was obtained in both replicates of one of the two experiments but not in the other experiment. For growing-finishing pigs on a corn-soy basal there were no differences in gain or feed efficiency when 0.1% lysine was fed with 14% protein lowered to 12% at 125 lb. However, with lower basal protein (11%, reduced to 9% at 125 lb.), 0.1% lysine brought about improvement of 11.6% in growth and 9% in feed efficiency. Significant differences ($P<0.01$) were found between protein levels, with or without lysine. This experiment was repeated with smaller differences between protein content of basal rations (14% lowered to 12%; 12.5% lowered to 10.5%). On the higher protein, 0.1% lysine improved gains. Lysine supplemented animals on low protein gained as much as those on high protein without lysine to 125 lb. Controls on low protein gained significantly less than any treated groups. Lysine supplementation of milo-soybean and corn-peanut meal (14% protein) rations for growing pigs brought about 12% and 26% improvement in rate of gain, respectively. Gains and feed efficiency on corn-peanut meal plus lysine were equal to those on milo-soy without the supplement.

132. LYSINE AND ENZYME SUPPLEMENTATION OF CORN AND BARLEY BASE DIETS FOR GROWING-FINISHING SWINE. H. E. Nielsen, V. W. Hays, V. C. Speer, J. D. Jones and D. V. Catron, *Iowa State University of Science and Technology.*

Four experiments involving 601 pigs were conducted to study the effect of supplemental L-lysine (1.0 lb./ton) in corn-soybean oil meal diets of varying protein levels (Exp. 1, 2 and 3) and supplemental L-lysine and enzymes (2 lb. Zymopabst/ton) when added to corn-soybean oil meal and barley-soybean oil meal diets. The first experiment compared two protein levels (14% reduced to 12%, and 12% reduced to 10% at 125 lb. body weight) with and without supplemental lysine. Pigs on the higher protein levels gained at a 28% faster rate on 10% less feed than those fed the lower protein levels. Those receiving supplemental lysine gained faster as compared

to the controls (1.45 vs. 1.39 and 1.14 vs. 1.08 lb./day for the high and low protein levels respectively). Lysine improved feed conversion only on the lower protein level (3.75 vs. 3.99 lb. feed/lb. gain). In a second experiment pigs were initially fed diets containing 14% protein and the protein level reduced 2 percentage units at 75 and 150 lb. body weight. Supplemental lysine resulted in 5% faster gains on 7% less feed. In a third experiment involving three levels of protein (16%, 14%, and 12% initially and reduced to 14%, 12%, and 10% at 125 lb. body weight) supplemental lysine improved gains on the low protein level (1.58 vs. 1.42 lb./day). A fourth experiment involved corn-soybean oil meal and barley-soybean oil meal diets (14% protein) supplemented with lysine, enzymes or a combination of lysine and enzymes. Lysine significantly improved the rate of gain (1.47 vs. 1.39) and feed conversion (3.09 vs. 3.24) of the pigs receiving the barley diets. Supplemental enzymes also improved feed conversion in the barley diets (3.14 vs. 3.19). Neither supplement improved performance on the 14% protein, corn-soybean oil meal diet when fed to pigs from 45 to 125 lb. body-weight.

133. EFFECT OF LYSINE-METHIONINE SUPPLEMENTATION ON GROWTH OF YOUNG PIGS FED A HIGH ENERGY-LOW PROTEIN DIET. P. R. Noland, John Mitchell, Jr., and K. W. Scott, *University of Arkansas.*

Replicate groups of six-week-old pigs were self-fed a 12% protein-1200 Calorie (Productive Energy) fortified corn-soybean meal-fat ration in wire-floored pens for 3 weeks. Zero, 0.2, 0.4, and 0.6% of L-lysine was added both in the presence and absence of 0.2% dl-methionine. Daily gains and feed required per pound of gain in the absence of methionine were 0.44, 3.51; 0.60, 2.60; 0.75, 2.18; 0.66, 2.37, respectively, for the four levels of lysine. In the presence of methionine the gain and feed efficiencies were 0.66, 2.82; 0.74, 2.30; 0.61, 2.74; 0.74, 2.32, respectively, for the four levels of lysine. Analysis of variance of gains indicated a significant response from lysine ($P=.05$). The lysine effect was primarily linear. Analysis of feed required per pound of gain indicated a significant linear ($P=.05$) response from lysine. In one test the addition of 0.2, 0.4 or 0.6% glycine produced gains equal to those produced by lysine or a combination of lysine and methionine. Lysine addition improved feed efficiency more than glycine. None of the gains or efficiencies approached the performance of pigs fed a 20% protein-1200 Calorie ration.

134. EFFECT OF SOURCE OF PROTEIN ON THE ZINC REQUIREMENT OF THE GROWING PIG. W. H. Smith, M. P. Plumlee and W. M. Beeson, *Purdue University Agricultural Experiment Station.*

Five groups of eight three-week-old pigs each were fed semi-purified rations containing 20.5% protein. The protein sources tested and the total zinc content of the respective rations in mg./kg. were (1) isolated soybean protein, 16; (2) soybean oil meal, 22; (3) vitamin-free casein, 6; (4) commercial casein, 18; and (5) dried skimmed milk, 16. Daily gains were 0.13, 0.27, 0.47, 0.46 and 0.67 lb. for ration 1 through 5, respectively, for 5 weeks. Feed required per lb. of gain was 6.86, 3.36, 2.02, 2.26 and 2.10 lb., respectively. All pigs receiving isolated soybean protein and soybean oil meal developed symptoms of parakeratosis, but there were no symptoms in the pigs fed milk proteins. At the end of 5 weeks the pigs were reallotted on the basis of previous gain. One-half of the pigs from each lot were continued on the previous rations and the other half on their previous ration supplemented with zinc at a level of 50 mg./kg. Daily gains were —.15, —.05, 1.31, 1.33 and 1.50 lb. for pigs fed rations 1 through 5 with no added zinc, respectively. The pigs fed the rations supplemented with zinc (50 mg./kg.) gained 1.10, 1.55, 1.02, 1.17 and 1.51 lb. day/pig for rations 1 through 5, respectively. Significant increase ($P<0.01$) in growth and alleviation of parakeratosis were observed when zinc was added to soybean protein rations (lots 1

and 2). The addition of zinc to the milk protein rations did not improve growth. In the repletion studies (phase 3), dried skimmed milk gave partial recovery from parakeratosis, but Cu at a level of 125 mg./kg. of ration gave no response.

135. INFLUENCE OF LEVEL AND SOURCES OF PROTEIN ON THE FECAL FLORA OF BABY PIGS. R. D. Wilbur, T. F. Kellogg, L. Y. Quinn, V. C. Speer, V. W. Hays and D. V. Catron, *Iowa State University of Science and Technology.*

In corn-soybean oil meal diets, increasing levels of protein from 10% to 30% generally improved both 4-week gain and feed conversion in baby pigs weaned at 3 weeks of age. However, the 30% level of protein gave slightly poorer gains than the 25% level. Changes in fecal populations of lactobacilli and coliforms were closely related to rate of gain. Total aerobes and total anaerobes followed similar but less closely related patterns. With constant levels of corn (the carbohydrates balanced as closely as possible by the interchange of starch and lactose) the following protein sources were studied: Soybean oil meal (SBOM), cottonseed meal (CSM), dried skim milk (DSM), fish meal (FM), and meat and bone meal (MB). Gains and feed conversion were superior for the DSM diet followed in order by SBOM, FM, CSM and MB. Changes in fecal lactobacilli again appeared to be related to rate of gain but changes in the coliforms were more closely associated with the source of protein (animal vs. plant).

136. EFFECT OF FEED ADDITIVES ON GAIN, FEED EFFICIENCY AND CARCASS QUALITY OF GROWING-FINISHING SWINE. J. H. Conrad, C. E. Jordan and W. M. Beeson, *Purdue University.*

Eleven feed additives or combinations of feed additives were tested with 192 thirty-five-lb. Duroc weanling pigs in two growing-finishing experiments. The treatments, levels in grams per ton, daily gains and feed per 100 lb. of gain, respectively, in Expt. 1 were (1) control, 1.43 and 360; (2) chlortetracycline 5, oxytetracycline 5, penicillin 2.5, and zinc bacitracin 7.5, 1.55 and 333; (3) penicillin 5 and zinc bacitracin 15, 1.53 and 351; (4) penicillin 3.3, streptomycin sulfate 8.4 and sulfaquinoxaline 8.3, 1.62 and 343; (5) arsanilic acid 90, 1.54 and 332; (6) 3-nitro-phenylarsonic acid 22.5, 1.50 and 347; (7) arsenobenzene 19, 1.37 and 365; (8) piperazine phosphate 400, 1.39 and 373. Pigs in the first four treated groups gained significantly faster than the control group but there were no significant differences due to any treatment in the carcass criteria measured (dressing percentage, carcass length, backfat, lean cut yield and loin eye area). The treatments, levels in grams per ton, daily gains and feed per 100 lb. gain, respectively, in Expt. 2 after 84 days were (1) control, 1.09 and 330; (2) same as group 2 above, 1.44 and 311; (3) arsanilic acid 90, 1.39 and 313; (4) erythromycin thiocyanate 10, 1.51 and 314; (5) oleandomycin 2 and oxytetracycline 8, 1.45 and 313; (6) penicillin 5 and streptomycin sulfate 15, 1.52 and 316; (7) penicillin 3.3, streptomycin sulfate 8.4 and sulfaquinoxaline 8.3, 1.54 and 316; (8) spiramycin 20, 1.58 and 313. All treated groups gained significantly faster than the control group.

137. OLEANDOMYCIN, TERRAMYCIN AND A COMBINATION PENICILLIN, STREPTOMYCIN AND SULFAQUINOXALINE FOR GROWING FINISHING SWINE. S. A. Griffin, B. A. D'Souza and C. C. Chamberlain, *University of Tennessee Agricultural Experiment Station.*

Fifty-six weanling Duroc and Hampshire pigs were allotted to 14 lots on the basis of weight, sex and breed. Two lots of four pigs each were randomly assigned to each of the following treatments: (1) Control, (2) Control plus 10 gm. oxytetracycline (Terramycine), (3) Control plus 3 gm. oleandomycin, (4) Control plus 12.5 gm. sulfaquinoxaline, 5 gm. penicillin and 12.5 gm. streptomycin, (5) Control plus 6 gm.

oxytetracycline, 2 gm. oleandomycin, (6) Control plus 5 gm. oxytetracycline, 6.25 gm. sulfaquinoxaline, 2.5 gm. penicillin, and 6.25 gm. streptomycin, (7) Control plus 2 gm. oleandomycin, 6.25 gm. sulfaquinoxaline, 2.5 gm. penicillin, and 6.25 gm. streptomycin. The pigs were fed in concrete pens from an average starting weight of 46 lb., to a weight of about 200 lb. Treatment number, average daily gain and feed required per 100 lb. gain are, respectively, (1) 1.53, 320; (2) 1.59, 320; (3) 1.38, 346; (4) 1.54, 331; (5) 1.50, 334; (6) 1.44, 327; and (7) 1.58, 314. There was no statistically significant difference among treatments in average daily gain or feed required per 100 lb. of gain. The pigs fed oxytetracycline (treatment 2) gained 3.9% faster than the controls; and the pigs fed the combination of oleandomycin, sulfaquinoxaline, penicillin and streptomycin (treatment 7) gained 3.3% faster than the controls.

138. DEEP LITTER VS. DRY LOT FOR GROWING-FINISHING PIGS WITH AND WITHOUT ANTIBIOTIC SUPPLEMENTATION. E. A. Rutledge and H. S. Teague, *Ohio Agricultural Experiment Station.*

A total of 192 pigs were used in a two-season study to determine the response of growing-finishing swine to antibiotic supplementation on deep litter or in dry lot. Pigs, 7–9 weeks of age were assigned to replicated lots of eight pigs each. In the deep litter system of management ground corn cobs were added to a depth of 10 inches and permitted to build up to a depth of aproximately 20 inches during the experimental period. The litter remaining from the first trial was used at the beginning of the second trial. The dry lot pens were bedded with straw and cleaned daily Monday through Friday of each week. In both trials, on deep litter and in dry lot, the treatment and/or amount of antibiotic per ton of feed was (1) control (2) 20 gm. Aureomycin (3) 10 gm. Aureomycin, 7.5 gm. zinc bacitracin and 2.5 gm. penicillin. In trial I the pigs fed on deep litter grew at a slower rate than those in dry lot. Both treatments 2 and 3 increased gains slightly (1.9%) but failed to improve feed efficiency. In dry lot, a greater improvement in growth rate was observed when the same antibiotics were fed. Treatments 2 and 3 increased gains 12.2 and 6.7%, respectively, while only treatment 2 improved feed efficiency. In the second trial, pigs fed the control ration on deep litter gained faster and more efficiently than those fed the same ration in dry lot. Under these conditions there was no growth response to antibiotic supplementation. A consistant and greater growth response to antibiotic supplementation was again observed in the second trial in dry lot. Treatment 2 and 3 increased gains 7.9 and 9.2% and resulted in a saving of 10 and 13 lb. feed/100 lb. gain, respectively.

139. EFFECT OF ERYTHROMYCIN IN COMPLETE AND FREE-CHOICE RATIONS FOR SWINE. Richard C. Wahlstrom and Eldon W. Juhl, *South Dakota Agricultural Experiment Station.*

Three trials were conducted with 196 pigs weaned at 4 weeks and fed starter rations to 8 weeks. In all trials pigs fed erythromycin gained faster and more efficiently than the controls and similar to those fed chlortetracycline. Erythromycin was fed at levels of 5, 10, 25 and 50 gm. per ton of feed and chlortetracycline at 50 and 100 gm. per ton. Pigs fed growing-finishing rations with erythromycin at 10 gm. per ton gained significantly faster than control pigs and also faster than pigs fed oxytetracycline and chlortetracycline at 10 and 20 gm. per ton, respectively. Chlortetracycline at 100 gm. per ton was superior to erythromycin at 5, 10, 25, or 50 gm. per ton. Erythromycin at 2 and 5 gm. per ton failed to produce a growth response. In two trials erythromycin was added to protein supplements fed free-choice to growing pigs. Protein consumption and rate of gain were decreased during the first 2 to 4 weeks. The pigs appeared to become accustomed to the supplements, as, after this initial period, there was very little difference in protein supplement consumption.

140. EFFECTS OF FOUR LEVELS OF CHLORTETRACYCLINE INTAKE ON BEEF CALVES AFTER WEANING. C. E. Haines, H. L. Chapman, Jr. and J. R. Crockett, *University of Florida.*

Two trials were conducted to determine the valve of daily intakes of 0, 45, 90 and 180 mg. of chlortetracycline by weanling beef calves. Trial 1 (1957) involved 112 calves for 84 days postweaning and trial 2 (1958) 140 calves for 98 days postweaning. Calves were hand-fed 4 lb. daily of a concentrate mixture containing the antibiotic, while on pasture. In trial 1, calves receiving levels of 0, 45, 90 and 180 mg. of chlortetracycline gained an average of 1.48, 1.18, 1.08, and 1.18 lb. daily, respectively. Calves in Trial 2 gained an average of 1.21, 1.25, 1.39 and 1.40 lb. daily for the four levels of antibiotic supplementation. In both trials, male calves gained faster than females. Calves receiving the higher levels of chlortetracycline in Trial 2, were in the most thrifty condition at the end of the study.

141. RELATION OF CRYSTALLINITY TO DIGESTIBILITY OF FEEDSTUFF CELLULOSE. Don C. Tomlin and George K. Davis, *University of Florida.*

Following the discovery by *Baker et al.* (J. Animal Sci. *18:* 655, 1959) that the crystallinity of purified celluloses was inversely correlated with their rate of digestion in the artificial rumen, a method was worked out to obtain estimates of crystallinity of celluloses from a variety of feedstuffs. The method involved chemical extraction of the feedstuff to get a relatively pure cellulose which gave a typical crystallographic pattern in the X-ray diffractometer. Digestibility of the cellulose in the feedstuffs was determined by weighing samples into small nylon bags and placing the bags in the rumens of three fistulated steers for 30-hour periods. Cellulose remaining in the bags was determined by the Crampton-Maynard method and calculated as the percent undigested in 30 hours. Feeds used, percent cellulose digested, and cellulose crystalline index were as follows: Solka-floc SW-40-A, 77.8, 5.8; purified cotton linters, 53.8, 9.2; sugarcane bagasse, 31.5, 2.6; Alyce clover hay, 46.4, 2.9; citrus pulp, 89.4, 1.5; and Bermuda grass hay 50-I, 48.6, 2.2 in the first trial. In the second trial: Bermuda 50-I, 51.3, 2.2; Bermuda 50-II, 42.0, 2.0; Bermuda 100-I, 45.6, 2.1; Bermuda 100-II, 40.0, 2.2; and Bermuda 200, 56.9, 2.4. These differences in cellulose digestibility were highly significant but, except for the two purified celluloses and possibly the citrus pulp, there was no relation between crystallinity and digestibility. Other factors in the hays and bagasse apparently had much more effect on cellulose digestibility.

142. THE EFFECTS OF PHLORIZIN, INSULIN, AND BUTYRATE ON BLOOD GLUCOSE CONCENTRATION AND KETONE FORMATION IN RUMINANTS. J. R. Staubus, R. E. Brown and C. L. Davis, *University of Illinois.*

The following treatments were applied to a 350-lb. Holstein steer which had been fasted 24 to 96 hours: (1) phlorizin, (2) phlorizin + insulin, (3) butyrate, (4) butyrate + phlorizin and (5) butyrate + phlorizin + insulin. Phlorizin in isotonic mannitol solution was infused intravenously to provide 10+ μg./kg./min. Butyric acid, neutralized with NaOH, was infused intravenously to provide 25 gm. of butric acid per hour. Insulin was injected intramuscularly at 0 and 4 hours in 400 unit quantities. All treatments were applied for 8 hours. Treatment (1) caused a gradual decrease in blood glucose to 30.4 mg.% and all others rapidly reduced it to less than 20 mg.%. Butyrate alone depressed blood glucose almost as much as insulin. These low levels of blood glucose were maintained for 6 hours without the appearance of hypoglycemic shock. The maximum levels of ketones observed in the blood were 6.0, 4.4, 5.5, 20.9 and 9.3 mg.%, respectively. The use of phlorizin, which lowers the "renal threshold" of glucose, caused 55.81 (1), 30.81 (2), 51.62 (4) and 38.13 (5) gm. of glucose to be voided in the urine in 8 hours. The infusion of 25 gm. of neutralized butyric acid per hour caused sharp increases in blood butrate but no adverse physiological response was

observed. No significant amount of butyrate appeared in the urine. More than 185 gm. of butyric acid were apparently metabolized by the steer in 8 hours. Ketone buildup was highest when the steer was subjected to low blood glucose levels, an uncontrollable glucose drain and high levels of ketogenic substances.

143. CHLORTETRACYCLINE EFFECT ON RUMEN CELLULOLYTIC ACTIVITY STUDIED *IN VIVO* WITH COTTON FABRIC. W. J. Byer and N. N. Allen, *University of Wisconsin.*

A technique was developed to measure *in vivo* changes in rumen cellulolytic activity. A small square of cotton gauze was weighed, stapled between plastic window screening, weighted with a 65 gm. steel sphere, attached to a 40 in. silk cord, and suspended inside the rumen of fistulated Holstein cows. Digestion of the cotton was determined gravimetrically after appropriate cleaning following 24 hr. of digestion. Several variables were studied in developing the technique including type of fabric, sample size, digestion time, length of cord, amount of weight, and sample treatment before and after digestion. Four cows on a uniform diet of hay and grain received chlortetracycline at levels of 0, 10, 20, and 40 mg. per hundred lb. body weight in a latin square design trial with 2-week periods and no change-over time. A single reversal trial followed immediately consisting of two cows on each level of 0 and 40 mg. per cwt. for 3-week periods without change-over time. No immediate effects were noted in either trial at any level of antibiotic. An analysis of variance showed no significant effect of treatment or level in either trial. The mean digestion of 262 observations at each level of 0 and 40 mg. per cwt. was 52.1% and 53.5% respectively. A paired "t" test showed this to be non-significant at the 5% level. The cellulolytic activity curves varied irregularly throughout both trials. Since environmental conditions were carefully standardized this is believed to be the result of normal changes in rumen bacterial population.

144. STUDIES WITH THE CELLULOLYTIC FRACTION OF RUMEN BACTERIA OBTAINED BY DIFFERENTIAL CENTRIFUGATION. Burk A. Dehority, Khaled el-Shazly and Ronald R. Johnson, *Ohio Agricultural Experiment Station.*

Suspensions of bovine rumen bacteria were separated into four fractions by means of differential centrifugation. These fractions were then tested for their ability to digest cellulose *in vitro*. Centrifugation was carried out at 250 x G for 3 minutes, 1500 x G for 10 minutes, and 3000 x G for 20 minutes. The supernatants thus obtained gave the following cellulose digestion in 30 hours: whole suspension, 1.18 gm.; 250 x G supernatant, 1.25 gm.; 1500 x G supernatant, 1.32 gm.; and 3000 x G supernatant, 0.18 gm. Cellulose digestion of the sediments was: 250 x G sediment, 0.72 gm.; 1500 x G sediment, 0.70 gm.; and 3000 x G sediment, 1.15 gm. These data suggest that the rumen bacteria primarily concerned with the digestion of cellulose remain in suspension when centrifuged at 1500 x G, but are sedimented at 3000 x G. The ratio of mg. cellulose digested to mg. TCA insoluble nitrogen in the inoculum rose from 69 for the whole suspension to 316 for the 3000 x G sediment. When ovine rumen bacteria were separated by this technique very similar results were obtained. All of the sediments were examined microscopically, and after incubation of those flasks containing the 3000 x G sediment a predominance of gram-negative micrococci and a smaller number of very small gram-negative rods were present, which were the two major groups of bacteria in this inoculum. Analysis of the 3000 x G sediment fermentations for end-products revealed primarily propionic and acetic acids, along with lesser amounts of succinic acid. Studies on the fatty acid requirement of these cellulolytic organisms suggests that it can be satisfied by valeric acid, and that a branched-chain acid is not required.

145. RAPID METHOD OF DETERMINING DIGESTIBILITY OF CONCENTRATES AND ROUGHAGES IN CATTLE. E. S. Erwin and N. G. Elliston, *University of Arizona.*

Feed constituents and a numbered plastic cattle ear tag, for identification, were held in nylon bags (4 in. by 8 in.) tied closed with nylon fish line. Weighted chains were constructed from tygon tubing (½ in. by 18 in.) fitted with a lead-filled pipe (1½ in. x 1½ in.) molded in plastic. Each chain will hold 12 bags. As many as three chains at one time can be placed in the anterior dorsal sac of the rumen through a fistula. After a certain time in the rumen, weight loss or digestibility of the feed-stuff in bags was studied. Four fistulated steers were used to evaluate this technique; milo grain (M), barley (B), barley straw (S), and alfalfa hay (A) were studied in all trials. The position of the bag on a chain or between chains within a steer did not influence digestibility. As the amount of feed was increased from 10 to 24 gm. digestibility was linearly decreased in A, S, B, 4.0–5.5% while M was reduced 15%. Variation of digestibility of feeds placed in the rumen 3, 6, and 9 hr. were A(26–34%), S(16–19%), B(37–54%), and M(27–36%). Fineness of grind of feed-stuff had less effect on digestibility as time of incubation was increased. In all studies the digestibility of M was 10–25% less than B. Increased digestibility due to fineness of grind increased M digestion twice as much as B. Although digestibility of all feed-stuffs was lowered in steers fed S when compared to A, the digestibility of feed-stuffs was comparable. The technique now used at Arizona consists of 20 gm. of feed in bags tied to chains and placed in the rumen for 9 hr.

146. GAMMA IRRADIATION AND SUBSEQUENT DIGESTION IN THE RUMEN OF CELLULOSE AND VARIOUS ROUGHAGES. C. B. Ammerman, J. L. Evans, D. C. Tomlin, L. R. Arrington and G. K. Davis, *Florida Agricultural Experiment Station.*

Samples of cotton linters, peanut hulls, corncobs and sugar cane bagasse were gamma irradiated at a rate of 4000 to 4200 roentgens per minute to yield total doses of 0, 10, 20 and 40 megaroentgens. Cellulose and crude fiber determinations were made on each sample. The cellulose digestibility of each sample was determined by the disappearance of cellulose from dacron bags suspended in the rumen of fistulated steers. The crude fiber (A.O.A.C. method) and cellulose of each sample decreased with each increase in level of irradiation. Samples irradiated at the level of 40 megaroentgens contained an average of 8% less cellulose and 56% less crude fiber than did the control samples. The effect of irradiation on the digestibility of the remaining cellulose varied with source.

147. BIOCHEMICAL AND MICROSCOPICAL COMPARISON BETWEEN *IN VIVO* AND *IN VITRO* RUMEN FERMENTATIONS. K. el-Shazly, R. R. Johnson and B. A. Dehority, *Ohio Agricultural Experiment Station.*

Four sheep on synthetic diets and a fistulated steer on a hay diet were used in this study to determine the authenticity of the microorganisms which ferment cellulose and other food constituents *in vitro*. After fasting 20 hours, samples were obtained from the rumen for use as inoculum in the *in vitro* studies. Samples of the substrate being studied were then introduced into the animal's rumen. Volatile fatty acid production was used as a criterion of digestion for cellulose, starch, casein and hay, in addition to the production of ammonia nitrogen for the last two substrates. The results indicated a definite parallelism in the rates of fermentation of cellulose *in vivo* and *in vitro* for the first 12 hours. Further studies on the direct measurement of

cellulose breakdown *in vivo* and *in vitro* were carried out, using the nylon bag technique *in vivo*. Comparison of the rates of digestion over a 48-hour period revealed a striking similarity between the *in vivo* and *in vitro* fermentation. Careful microscopic examination before and after the *in vitro* fermentation revealed a proliferation of gram-negative micrococci and very small rods, which were also found in the original inoculum in large numbers. These same organisms were also observed to proliferate *in vivo*. When hay or a complete synthetic diet was used as substrates, no appreciable changes in the flora were observed over the 24–30 hour fermentation period. However, with starch as the sole substrate, a proliferation of different organisms occurred in different experiments. It is concluded that the Ohio *in vitro* system used for cellulose digestion is representative of conditions *in vivo* over a period of 24–30 hours.

148. RATE OF ACETATE UTILIZATION IN THE SHEEP STUDIED WITH RADIOACETATE. H. W. Essig and B. Connor Johnson, *University of Illinois.*

Two yearling lambs which had been trained to wear a face mask for long periods of time were used in two experiments to ascertain the energy metabolism of acetate. Metabolism of acetate was studied by using the following criteria: the determination of a rate of disappearance of acetate from jugular blood, the determination of the half-life of acetate–1–$C^{14}$ in jugular blood, and the determination of the percent of acetate disappearing from jugular blood which was metabolized to $CO_2$. Acetate–1–$C^{14}$ was infused for 1 hour during the third to fourth hour of the fed state. Jugular blood and $CO_2$ samples were taken at varying time intervals during and after acetate–1–$C^{14}$ infusion. In experiment 1, the rate of disappearance of acetate was calculated to be 9.7 millimoles per minute per sheep, which is equivalent to 35 gm. (122 kilocalories) per hour per sheep. The half-life of acetate–1–$C^{14}$ in jugular blood was calculated to be 0.37 minute, and 39% of the acetate–1–$C^{14}$ disappearing from jugular blood was metabolized to $C^{14}O_2$. In experiment II, the rate of disappearance of acetate was calculated to be 10.9 millimoles per minute per sheep, which is equivalent to 39 gm. (137 kilocalories) of acetic per hour per sheep. The half-life of acetate–1–$C^{14}$ in jugular blood was calculated to be 0.47 minute, and 46% of acetate–1–$C^{14}$ disappearing from the jugular blood was metabolized to $C^{14}O_2$.

149. THE EFFECT OF CORN STEEPWATER AND LACTIC ACID ON ANIMAL PERFORMANCE AND DIGESTIBILITY WHEN ADDED TO NATURAL AND PURIFIED RUMINANT RATIONS. Ronald R. Johnson, Earl W. Klosterman, John E. Moore and Harold W. Scott, *Ohio Agricultural Experiment Station.*

The presence of lactic acid in silages and corn steepwater has stimulated a study of its energy value. In an 84-day lamb feeding test, high-fiber lamb rations (soyhull-corncob-corn) were supplemented with corn steepwater and 3.5% and 7.0% lactic acid. Although corn steepwater did not improve performance, lactic acid had feed replacement values of 2.27 and 3.25, respectively. In a 71-day trial with 12 individually fed steers fed a purified ration (30% cellulose), 4% and 8% levels of lactic acid had replacement values of 0 and 2.88, respectively. Current steer feeding trials with natural rations reveal similar figures. These data agree with those reported from this laboratory by Bentley *et al.* (J. Animal Sci. 13:976, 1954). In a digestion trial with lambs fed a 50% roughage ration (soyhulls- corncobs-starch-corn), the apparent digestion coefficients with the basal and 7.5% corn steepwater rations were dry matter, 62.6 and 66.5; crude fiber, 33.6 and 51.6; cellulose, 35.6 and 50.2; and protein, 60.8 and 52.2. Digestion trials are now underway using purified rations supplemented with corn steepwater and lactic acid.

150. THE DIGESTIBLE CELLULOSE REMAINING IN THE FECES OF SHEEP FED DIFFERENT ROUGHAGES AS DETERMINED BY *IN VITRO* RUMEN FERMENTATIONS. Ronald R. Johnson, Harold W. Scott, A. L. Moxon and O. G. Bentley, *Ohio Agricultural Experiment Station.*

Recent work in this laboratory (Quicke *et al.*, J. Animal Sci. 18:275, 1959) has demonstrated the value of the *in vitro* rumen fermentation procedure for determining digestibility of the cellulose in roughage samples. Using this technique, Moxon and co-workers (J. Animal Sci. 17:1193, 1958) reported that the cellulose in the feces voided by sheep being fed soybean hulls was still quite digestible. It was of interest to compare these values to the digestibility of cellulose in feces of ruminants on other roughages. Average percent digestibilities of the cellulose in the feces of sheep on different roughages were as follows: soybean hulls, 76.52; brome grass hay, 5.25; orchard grass hay, 5.34; alfalfa, 16.01; and corn silage, 28.98. It is obvious that the available or digestible cellulose in the ration was more efficiently used in brome grass and orchard grass than in alfalfa and silage. In another trial, the digestible cellulose was lowered from 66.8% in the feces of control animals on a soyhull-corncob-cornstarch ration to 58.5% by supplementing the ration with corn steepwater. When soybean hulls were full-fed and fed at half the full-feed level, the feces cellulose was 73.60% and 59.28% digestible, respectively. Comparisons of total available cellulose and cellulose digested may give an indication of both rate of digestion and rate of passage.

151. METHODS FOR INCREASING THE ORGANIC ACID CONTENT OF WHOLE PLANT AND GROUND EAR CORN SILAGES AND THEIR FEEDING VALUE FOR FATTENING CATTLE. Earle W. Klosterman, Ronald R. Johnson, Harold W. Scott, Jack Van Stavern and A. L. Moxon, *Ohio Agricultural Experiment Station.*

Experiments with small laboratory silos indicated that the organic acid content of whole plant and ear corn silages was directly related to the amount of moisture in the material ensiled. It was also found that acid production during ensiling could be increased approximately 100% by the addition of 1% calcium carbonate. Whole plant corn was ensiled in conventional silos with and without the addition of 1% dolomitic limestone. This addition increased total acid production by 42%. These two silages were fed to triplicate lots each of seven steers for an 84-day period. Gains of the steers were nearly equal with a tendency for those fed the treated silage to require slightly less silage dry matter per unit of gain. In addition, ear corn was picked when the whole ears contained 47% moisture. One-third was ground through a burr mill and ensiled; one-third was ground and ensiled with 1% dolomitic limestone; and, one-third was artificially dried. These were fed to triplicate lots of steers for 119 days. There was little difference in performance of steers fed the treated or untreated ear corn silages. However, they gained slightly faster and required, on the dry corn basis, 15% less corn per hundredweight gain than those fed the dry corn. Digestion experiments with lambs showed that the limestone addition did not decrease the digestibility of organic matter, crude fiber, cellulose or protein of the whole plant corn silage.

152. ALFALFA CONCENTRATES FOR STIMULATING CELLULOSE DIGESTION. J. A. Liuzzo, S. L. Hansard, A. F. Novak and J. G. Lee, *Louisiana State University.*

This experiment was conducted to determine if alfalfa concentrates prepared by Novak, Jonnard and Liuzzo (J. Am. Pharm. Assoc. 47:413, 1958) were active in stimulating cellulose digestion in the artificial rumen. The technique involved acid-extraction of alfalfa leaf meal, precipitation of extract with ethanol, extraction of ethanol filtrate with ether and chloroform, absorption and elution of solvent insoluble fraction on Fuller's Earth and Darco. Chromatography was used to separate compounds

present in the Darco eluate. They were eluted from the chromatograms and tested for activity. The technique of Cheng *et al.* (J. Dairy Sci. 38:1225, 1955) was used for the artificial rumen determination. The Darco eluate (final concentrate), when added at a level equivalent to 0.8 gm. of alfalfa, increased cellulose digestion from 30.2% to 52.8%. The Darco eluate chromatogram was divided below proline. The upper part of the chromatogram contained leucine, isoleucine, valine, γ-aminobutyric acid, and proline. Eluates of the upper and lower parts increased cellulose digestion to 40.5% and 43.3%, respectively. Dehority *et al.* (J. Animal Sci. 16:502, 1957) did not obtain stimulation with compounds below proline. Therefore, an unidentified celluloylytic factor has been concentrated by this technique.

153. UTILIZATION OF ACETATE BY OVINE LIVER. A. R. Schulz, H. Kang, Y. Lin, M. Turner, and A. D. Tillman, *Oklahoma State University*.

It has recently been suggested on the basis of data obtained with the use of carboxyl-labeled acetate that acetate is not utilized by bovine liver. We have initiated a detailed study of volatile fatty acids by ovine tissues. With the use of classical manometric techniques, we have found that ovine liver mitochondria are *capable* of utilizing acetate. Washed liver mitochondria require the presence of catalytic amounts of a Kreb's cycle intermediate for acetate oxidation. Acetoacetic acid does not accumulate either in presence or absence of a Kreb's cycle intermediate. The oxidation of butyrate catalyzed by ovine liver mitochondria is also stimulated by the addition of a Kreb's cycle intermediate. However, with butyrate there is considerable oxygen uptake even in the absence of an intermediate. This oxygen uptake in the absence of a Kreb's cycle intermediate appears to be due largely to the oxidation of butyrate to acetoacetate.

154. UREA NITROGEN UTILIZATION IN LAMBS AS INFLUENCED BY METHIONINE AND TRYPTOPHAN SUPPLEMENTATION. K. M. Barth, G. A. McLaren, G. C. Anderson, J. A. Welch and G. S. Smith, *West Virginia University*.

Previous studies on non-protein nitrogen (NPN) utilization at the West Virginia Station have involved feeding lambs semipurified rations in which approximately 82% of the supplemental nitrogen (N) was supplied by urea and 18% by soybean protein. In the present work, soybean protein was eliminated from the basal ration, and all of the supplemental N, representing 87% of the total N, was supplied by urea. Methionine and/or tryptophan was provided in the experimental rations in place of isonitrogenous amounts of urea. The semipurified rations fed to the lambs were composed of a purified concentrate mixture, blackstrap molasses and corn cobs, and contained 1.7% N. Methionine and tryptophan replaced 17% and 11%, respectively, of the urea N. Trial I was designed to consist of a 10-day preliminary period and two successive 10-day collection periods. This was done in order that the effect of time on N utilization of these high NPN rations might also be determined. Trial II consisted of a 10-day preliminary period and a 10-day collection period. Supplementation with either methionine or tryptophan or both amino acids increased ($P<.05$) the percentage retention of absorbed N. Feeding this high percentage of urea N for 35 days failed to produce urea toxicity symptoms, and the fasting levels of blood urea N and ammonia N were within normal ranges. Digestibility of nutrients was not influenced ($P>.05$) by either amino acid supplementation or time.

155. MULTIPLE REGRESSION OF COMPONENTS OF VARIATION IN UREA NITROGEN UTILIZATION. G. S. Smith, R. S. Dunbar, G. A. McLaren, G. C. Anderson and J. A. Welch, *West Virginia University*.

Observations from 63 lambs receiving a high-urea, semipurified ration (Campbell *et al.*, J. Animal Sci. 18:780, 1959) employed in 19 digestion and nitrogen metabolism

trials were subjected to multiple regression analysis in order to measure independently the effects of adaptation to urea feeding and of variations in the percentage of urea nitrogen in the rations and total ration nitrogen content. The equation, $Y=111.93-1.093X_1-1.065X_2+0.201X_3$, expresses the relationship of percentage retention of absorbed nitrogen (Y) to the percentage of nitrogen supplied by urea ($X_1$); the percentage of total nitrogen in the ration ($X_2$); and the length of time in days of continuous urea feeding ($X_3$). The coefficients indicate that the retention of absorbed nitrogen was (1) depressed ($P<.01$) by approximately 12% when the percentage of nitrogen supplied by urea varied from 54% to 68%; (2) not significantly affected by variation in the total nitrogen content from 1.5% to 2.0% when the urea level was constant; and (3) improved ($P<.001$) by approximately 0.2% per day of prolonged feeding of urea rations in the range of 10 to 50 days. Similar equations relating the digestibility of organic matter and crude fiber to ration content of crude fiber in addition to the variables already noted revealed that the variations in digestibility were associated primarily with ration variables and were not significantly related to the prolonged feeding of urea rations.

156. STUDIES ON LYSINE IN CATTLE AND LAMB NUTRITION. W. H. Hale, W. C. Sherman, W. M. Reynolds and P. P. Appel, *Chas. Pfizer & Co., Inc., Terre Haute, Indiana.*

The effect on gains and feed efficiency of two levels of supplemental L-lysine hydrochloride with two levels of protein was tested in a 2 x 3 factorial experiment with beef cattle of 600 lb. initial weight. Eight steers per lot were full-fed cracked shelled corn plus limited supplement, hay and ground cobs. The two protein levels were 8.6% and 11.5% of the ration. Supplemental lysine levels in rations of treatment groups were 4.0 and 10.0 gm. per steer daily. Fifty-six day results showed an increase in rate of gain due to protein level of 0.35 lb. per head daily, or 15%. There was relatively little effect of either supplemental lysine level on gains with the lower protein ration. Ten gm. of lysine with the higher protein ration increased average daily gain by 0.42 lb., or 15%, but there was no effect from 4.0 gm. The higher level of lysine improved feed efficiencies on both levels of protein. In a 68-day lamb fattening trial, one lot of 12 lambs was fed a complete pelleted ration containing 900 gm. of added L-lysine HCl per ton of ration. The basal ration was formulated of ground corn 53.5, sun-cured alfalfa meal 35, molasses 7, urea 1, bone meal 1, and bentonite 2.5, and contained 11.5% protein. The average daily gain of the lysine supplemented lot was 0.426 lb. and that of the replicated control lots was 0.32 daily.

157. PURIFIED DIET STUDIES: COMPARISON OF FOUR DIFFERENT PROTEIN SOURCES IN RATIONS FOR SHEEP. Robert Oltjen, Robert Sirny, and Allen D. Tillman, *Oklahoma State University.*

In earlier purified diet studies in this laboratory in which urea was the nitrogen source, the addition of highly alkaline ash (soybean meal or alfalfa) improved sheep gains. As later work with reagent grade mineral salts indicated that alkalinity of the mineral mixture was important, a modified mineral mixture was compounded which retained the high alkalinity of alfalfa ash. The composition of the mixture in percent was $K_2CO_3$, 31.55; $CaHPO_4$, 48.94; $MgSO_4$, 10.75; NaCl, 7.43; $FeSO_4$, 0.91; $MnSO_4$, 0.10; $Na_2B_4O_7$, 0.19; $CuCO_3$, 0.02; KI, 0.03; $ZnSO_4$, 0.07; $CoCl_2$, 0.0003; and $MoO_3$, 0.0008. This mineral mixture has given good results in sheep rations in which urea was the nitrogen source. The present trial compared casein (vitamin-free), soybean meal, and Drackett to urea in isonitrogenous diets, starch and corn sugar being altered when necessary. The composition of the urea diet in percent was corn starch, 24.1; corn sugar, 24.1; corn oil, 1.0; Solkafloc, 36.0; urea, 4.2; cottonseed hulls, 4.0; choline chloride, 0.1; mineral mixture, 6.5; and, vitamins A and D. Twenty-four

lambs (six per treatment) were used in a 48-day trial. Daily gains and feed efficiencies were in pounds, 0.31, 825; 0.32, 764; 0.36, 717; 0.39, 627 for urea, casein, soybean meal, and Drackett, respectively. Differences between urea and casein or between soy and Drackett were not statistically significant; however, both soybean and Drackett gave results significantly different from those of either urea or casein.

158. PHOSPHORUS, SULFUR, COPPER, AND MOLYBDENUM INTERRELATIONSHIPS AND THEIR EFFECTS UPON CELLULOSE DIGESTION *IN VITRO*. Joe L. Evans and George K. Davis, *University of Florida*.

A 24 factorial experiment, with five completely randomized replications in duplicate, was used. The concentrations of phosphorus were 283 and 1033 mcg. per ml.; sulfur, 25 and 775; copper 0.08 and 1.58; and, molybdenum 0 and 150. The optimum control contained 358, 100, 0.23 and 1.5, respectively. The optimum control produced a higher cellulose digestion coefficient, 35.7%, than the average of the factorial effects, 23.3. The copper-sulfur interaction showed that sulfur reduced the severity of the depression produced by copper. The phosphorus-copper-molybdenum interaction showed that when either copper or molybdenum was present at a level that depressed cellulose digestion by rumen inoculum, the addition of the other in the presence of a high level of phosphorus lessened the severity of the depression. Because of these existing interactions, positive effects of phosphorus and sulfur should be dealt with cautiously. The effect of each will depend on the level of the other interrelated nutrients. The addition of either sulfur or phosphorus to rumen inoculum improved cellulose digestion, and the improvements appeared additive. The high levels of phosphorus and sulfur mentioned above did not appear harmful when cellulose digestion was used as a measurement. The remaining first and second order interactions were not different from the experimental mean but were lower than the optimum control. Other data showed that the digestion of cellulose from Solka-Floc was highest; cotton linters, intermediate; and sugar cane bagasse, lowest. Grinding (40-mesh) cotton linters and sugar cane bagasse improved cellulose digestion.

159. EFFECT OF SEVERAL ENZYME CONCENTRATES ON CELLULOSE DIGESTION IN THE ARTIFICIAL RUMEN. D. W. Bowden and D. C. Church, *Oregon State College*.

In a series of artificial rumen experiments, crude rumen liquor from grazing steers was used to digest purified cellulose, barley straw, and dried grass. To each substrate varying amounts of the following products were added: (a) a feed-grade premix of a bacterial amylolytic-proteolytic enzyme preparation (Takamine HT440); (b) a concentrate of (a); (c) a fungal cellulase preparation (Takamine XT–541–12); (d) a fungal amylase (Takamine F8037); and, (c) a crude preparation of levulinic acid. Results of *in vitro* trials indicated that digestion of purified cellulose and cellulose in barley straw, but not in dried grass, might be improved by all of the test substances except (d); however, considerable variation existed between trials and the level of the test substance appeared to be critical. In a second series of experiments an attempt was made to identify the active factor(s) responsible for the increased cellulose digestion. It was shown that enzyme additions alone (no rumen liquor added) failed to increase cellulose digestion. Ashing completely inhibited activity; however, boiling for 5 to 20 min. did not. Hydrolysis with NaOH increased the cellulolytic activity in one experiment. Extraction with cold acetone or ethanol, and ppt. with TCA completely inhibited activity. Additions of proline, valine or valeric acid gave responses essentially similar to enzyme additions. Evidence indicates that any response which may be obtained in digestion or growth from addition of enzymic preparations to ruminant rations is not due to the enzymes, *per se*.

160. SUPPLEMENTARY ENZYMES AND LIVEWEIGHT GAIN STIMULATION IN BEEF CATTLE. Wise Burroughs, Walter Woods, S. A. Ewing, John Greig and Brent Theurer, *Iowa State University*.

The value of adding a dried enzyme mixture of bacterial origin (Agrozyme, supplied by Merck Sharp and Dohme Research Laboratories, contained both amylolytic and proteolytic enzymes as well as others) to beef cattle rations was investigated in 10 feeding experiments making use of 325 cattle divided into 43 experimental groups. The enzyme mixture was fed at the rate of either 0.0075 or 0.0150 lb. per animal daily incorporated in the protein supplemental allowance. Replicate lots, both enzyme-fed and control, were included in 9 of the 10 experiments. Both fattening and growing rations were fed either to steers or heifers for periods ranging from 84 to 175 days in the respective experiments. Rate of liveweight gain, feed consumption, feed required per unit of gain and carcass measurements including dressing percentage and federal grade were the primary criteria measured. The enzyme mixture increased liveweight gains by an average of 9% in 8 of the 10 trials. Little or no influence upon feed consumption was noted. However, efficiency of gain was improved in the enzyme-fed cattle an average of 6% in the 10 experiments. Dressing percent and federal carcass grade were not consistently improved although both measurements averaged slightly higher for the enzyme-fed cattle.

161. DIETARY ENZYME SUPPLEMENTS AND RATION DIGESTIBILITY IN STEERS AND LAMBS. Brent Theurer, John Greig, Walter Woods and Wise Burroughs, *Iowa State University*.

A series of digestion trials with steers and with lambs fed fattening type rations were conducted to determine the effect of a dried bacterial enzyme preparation (Agrozyme, supplied by Merck Sharp and Dohme Research Laboratories, contained both amylolytic and proteolytic enzymes as well as others) upon digestibility and nitrogen retention. The steer trials were conducted with two groups of eight steers each which received the following rations: (1) basal and (2) basal plus 7 gm. enzyme mixture. In the first steer trial a 12% protein ration was fed composed of 64% ground corn, 29% chopped alfalfa hay and 7% supplement, and in the second steer trial a 9% protein ration was fed composed of 60% ground corn, 10% chopped alfalfa hay, 14% corn cobs, 10% molasses and 6% supplement. The addition of the enzyme mixture decreased protein digestibility in the 9% but not in the 12% protein ration; it did not affect digestibility of dry matter, organic matter, and cellulose in either ration. Nitrogen retention was similar in control and treated steers. In the lamb trials, four groups of eight lambs each were fed the following daily rations: 800 gm. basal; basal plus 0.5 gm. enzyme mixture; basal plus 1.0 gm. enzyme mixture; and basal plus 2.0 gm. enzyme mixture. Nitrogen retention was increased although digestibility of the ration components was not significantly influenced by the enzyme supplementation.

162. EFFECT OF ADDING BACTERIAL AMYLASE TO MAMMALIAN DIETS. L. J. Classen, M. J. Smidt, F. D. Wharton, Jr., and J. C. Fritz, *Dawe's Laboratories, Inc., Chicago, Ill.*

Crude bacterial amylase preparations were added to practical rations for albino rats, rabbits, pigs, and lambs. While these fermentation products were standardized for alpha amylase activity, they did contain many other enzymes. The effect upon growth rate and feed was comparable to that previously reported for poultry. When graded levels of the enzyme were added to laboratory rat diets based on either corn or barley, the growth rate was increased by 7 to 41%. The enzyme addition to typical rabbit feeds increased the growth rate of rabbits by 9 to 20% and effected a 3 to 12% improvement in feed conversion. When amylase was added to swine rations of differing

composition, in four experiments, the rate of pig growth was increased by 8 to 14%, and feed conversion was improved by an average of 8%. Addition of the bacterial amylase to high corn supplements for fattening lambs resulted in a small, but not significant, increase in rate of gain.

163. INFLUENCE OF SOURCES OF ADDED FAT ON PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING-FINISHING BEEF STEERS. M. B. Wise, T. H. Jackson, E. R. Barrick and T. N. Blumer, *North Carolina Agricultural Experiment Station.*

Forty steers, 20 yearlings and 20 calves, were used to investigate the effect on performance and carcass characteristics of replacing 5% by weight of ground shelled corn with 5% of yellow grease, a blend of vegetable and animal fats, or cottonseed foots in a complete mixed ration based on ground ear corn. Feed (*ad libitum*) was offered over a test period of 125 days for the yearlings and 168 days for the calves. All animals received 24-mg. stilbestrol implants. Upon completion of the performance study the animals were slaughtered and various linear and width measurements made on the carcass. In addition the 9–12 rib section was removed for physical separation of fat, lean and bone, for chemical analyses and for objective measurements of fat distribution. Formulae were used to convert percentages obtained from the rib section to a carcass basis. In the performance study the daily gain in lb., TDN intake in lb. per day and lb. TDN per lb. of gain (after adjustment for maintenance) for the treatments were, respectively, Basal-2.7, 16.9, 4.0; Yellow Grease-2.4, 15.7, 4.1; Blend-2.4, 14.9, 3.8; and Cottonseed Foots-2.6, 16.2, 3.9. In the carcass evaluation the % separable fat, % separable lean, mm.$^2$ of marbling per sq. in. of ribeye muscle, rind thickness in mm. and ribeye area in sq. in. for the treatments were, respectively, basal-32.8, 55.4, 45.7, 21.8, 11.7; Yellow Grease-34.4, 54.7, 46.9, 24.1, 11.1; Blend-32.2, 55.9, 34.6, 19.3, 10.9; and Cotonseed Foots-33.5, 54.5, 38.3, 21.4, 11.3. The yearlings appeared to be able to utilize the fats to greater advantage than the calves.

164. THE EFFECT OF ORAL ADMINISTRATION AND MATERNAL TRANSFER OF SELENIUM AND VITAMIN E ON THE INCIDENCE OF MUSCULAR DYSTROPHY IN LAMBS. J. F. Proctor, D. E. Hogue, and J. M. King, *Cornell University.*

Previous research has indicated that selenium as well as vitamin E is involved in preventing muscular dystrophy in lambs. A known, low-selenium, dystrophogenic ration of mixed trefoil-grass hay and raw cull kidney beans was fed to 80 grade, pregnant ewes during the fall and winter of 1958–59. One month prepartum the ewes were assigned at random to the following treatments: (1) control group receiving the hay and cull bean basal, (2) basal ration plus 100 I.U. dl-alpha-tocopheryl acetate given to the ewes daily, (3) basal ration plus 1 ppm selenium as $Na_2SeO_3$ given to the ewes, (4) basal ration plus a dose equal to 50 I.U. of dl-alpha-tocopheryl acetate per day administered by stomach tube to the lambs every second day, and (5) basal ration plus 0.5 mg. selenium/day as an aqueous solution of $Na_2SeO_3$ administered as above to the lambs. In this manner it was possible to determine the effectiveness of placental and mammary transfer as compared to oral administration as well as to compare selenium and vitamin E. The additives given to the ewes were supplied in cerelose as the carrier and 1 lb. given to each group daily. The ewes in the control group and treatment lots 4 and 5 were given the same amount of plain cerelose. The incidence of diagnosed muscular dystrophy in the lambs of the five lots was: 15 of 25, 1 of 18, 1 of 21, 0 of 22, and 0 of 19, respectively. From this study it appears that selenium and vitamin E were equally effective and also that oral administration of either one to lambs is more effective than placental and mammary transfer.

165. CONDITIONED COPPER DEFICIENCY IN DAIRY CATTLE AND THE EFFECT OF FEEDING EXCESS COPPER TO NORMAL ANIMALS. D. Arthur, I. Motzok and H. D. Branion, *Ontario Agricultural College.*

Conditioned copper deficiency in cattle in eastern Ontario has been alleviated by feeding 2 gm. copper sulfate per head daily to mature animals or *ad libitum* eating of a mineral mixture containing 1 gm. copper sulfate per oz. to calves. Reports of the deleterious effect of excess copper feeding and the existence of only a marginal deficiency in this area prompted a study of feeding more than the recommended amounts of copper to healthy animals on a normal ration. Two groups of two cows each were fed two levels of copper sulfate, 3 and 5 gm. per animal daily in a mineral mixture for 3 years. No external symptoms of toxicity were observed and there was no abnormal variation from the average initial serum copper content of 100 μg./100 ml. Post mortem examination showed no abnormality. Average copper content of livers was 66 ppm on a wet-weight basis. Two calves aged 5 months were allowed to eat *ad libitum* a cattle mineral mixture containing 2 gm. copper sulfate per oz. for 1 year. Daily consumption varied from 1 to 1½ oz. per calf. The initial copper content of serum was 98 μg./100 ml. and the amount varied from 60 to 120 μg./100 ml. during the trial. Growth and condition appeared normal and there were no apparent abnormalities on post mortem. Average liver copper content was 80 ppm on a wet-weight basis.

166. THE EFFECTS OF EIGHT YEARS CONTINUOUS FEEDING OF DIFFERENT LEVELS OF FLUORINE AND ALLEVIATOR ON FEED CONSUMPTION, TEETH, BONES, AND PRODUCTION OF COWS. C. S. Hobbs and G. M. Merrimam, *University of Tennessee.*

The effects of daily feeding of fluorine (F) from sodium fluoride in levels of 28, 38, 48, and 58 ppm F and 28, 38, 48, 58 ppm F plus an alleviator, $Al_2(SO_4)_3$, at the rate of 0.5% of total ration were studied with 29 beef cows. The cows started on test at 1½ years of age and remained on test for 8 years. F added to the ration at 58 ppm caused a slight decrease in hay consumption after 3½ years. Cattle consuming this level of F plus $Al_2(SO_4)_3$ and those on all other treatments showed no decreased feed consumption. Increased levels of F without alleviator caused increased dental fluorosis. In all lots the addition of $Al_2(SO_4)_3$ decreased the amount of dental fluorosis as gauged by the index of incisor teeth condition. This reduction was greatest at F levels of 48 and 58 ppm. Ingestion of increased levels of F and F plus $Al_2(SO_4)_3$ caused progressively increased storage of F in various bones. In cattle in each treatment, the addition of $Al_2(SO_4)_3$ decreased bone F storage by 31% to more than 40%. Gross bone hypertrophy believed due to ingestion of F appeared on metatarsals in one cow on the 48 ppm F level and in the metatarsals and mandibles of the cows on the 58 ppm F level. No gross bone hypertrophy was found in cows on corresponding levels receiving $Al_2(SO_4)_3$ or in cows on the other treatments.

167. PALATABILITY STUDIES OF RATIONS AND RESPONSE TO AUREOMYCIN ADDITIONS BY SUCKLING LAMBS FED IN CREEPS. C. V. Ross and R. L. Pavey, *University of Missouri.*

Approximately 260 suckling lambs were used in four creep feeding experiments. In three palatability studies with 20 different feed ingredients or mixtures compared, lambs preferred certain feeds. Soybean oil meal was the most acceptable single ingredient and rations containing high percentages of it were consumed more readily than other mixtures. Rations fed in pelleted form were consumed more readily than the same mixtures fed as meal. Sugar, molasses, and corn syrup increased creep feed consumption. Thrifty lambs fed creep rations containing 10 mg. of Aureomycin per lb. of feed made no apparent response in 67 days on test. Later when the level of

Aureomycin was increased to 40 mg. per lb. of feed, lambs on Aureomycin gained 0.41 lb. per day compared with 0.38 for controls. No differences were observed between two lots of native lambs fed creep rations containing 10 mg. Aureomycin compared with 30 mg. Aureomycin per lb. of feed. In a third test, 60 thrifty spring lambs were divided into two uniform lots and creep fed for 77 days. Both groups received the same rations except for Aureomycin added at the rate of 30 mg. per lb. of feed to one group. Since pastures were excellent and ewes were heavy milkers, only small quantities of creep feed was consumed. Lambs on Aureomycin graded somewhat higher and appeared thriftier at the end of the test. Lambs on Aureomycin made daily gains of 0.50 versus 0.46 for controls. None of the differences were statistically significant.

168. THE EFFECT OF MOISTURE CONTENT OF FIELD-SHELLED CORN ON HARVESTING AND STORAGE LOSSES AND ON ITS FEEDING VALUE FOR BEEF CATTLE. G. L. Heuberger, G. E. Mitchell, Jr., W. W. Albert, and A. L. Neumann, *University of Illinois.*

Three experiments with a total of 80 yearling cattle have been conducted to compare the feeding value of field-shelled corn, stored in concrete stave silos at moisture contents of 24, 29, and 36% with dry shelled corn (14.5%) harvested from the same field. In experiment I the results from feeding 14.5, 24, 29, and 36% moisture corns to yearling heifers for 120 days were average daily gain 1.89, 1.90, 1.91, and 1.51 lb.; total lb. of corn consumed per day on 14.5% basis 12.96, 13.03, 12.99, and 11.15; and total lb. of feed required per cwt. gain 1048.0, 1043.0, 1040.0, and 1193.9, respectively. Heifers fed the 36% moisture corn consumed about 2 lb. per day less corn than heifers fed the other corns. This reduced intake resulted in slower ($P<.05$) and less efficient gains. Average digestion coefficients for 14.5, 24, and 36% moisture corn were energy 71.4, 72.0, 70.7; dry matter 72.9, 73.5, 71.9; ether extract 84.8, 82.2, 85.5; crude fiber 49.4, 51.6, 43.7; and nitrogen 66.7, 63.6, 62.8. In experiment III, with yearling steers, it was found that cattle may be placed on a full feed of shelled corn faster with high moisture corn (33%) than with dry shelled corn as 1 and 6 weeks were required to get cattle on full feed with wet and dry corn, respectively. Paired weighed samples of the various test corns were analyzed for nutrient changes during storage with one sample being analyzed at silo filling time and the other at feeding time. Percent losses in silos containing 24, 29, and 36% moisture corn were dry matter 2.16, 3.40, 1.19; gross energy 2.10, 4.83, 1.48; crude protein 1.31, 3.96, 0.33.

169. DICESTIBLE ENERGY DETERMINATIONS OF HIGH AND REGULAR MOISTURE CORN AND COB MEAL, CORN COBS AND SOY MILL FEED USING IDENTICAL TWIN BEEF CALVES. D. E. Hodge, M. P. Plumlee and W. M. Beeson, *Purdue University.*

Two sets of identical twin beef calves were used in a series of three digestion trials. The set of steers had an average initial weight of 648 lb. and the heifers an average weight of 882 lb. A 10-day collection period was preceded by a 7-day adjustment period. Energy determinations of the feed and daily fecal collections were made in a Parr adiabatic bomb calorimeter. The digestible energy was calculated on the basis of calories per gram of oven-dried feed (87° C for 48 hours). The amounts fed each twin of a set were equal on a dry matter equivalent basis and the daily intake was constant throughout each trial. The time between trials 1 and 2 was 5 weeks and between trials 2 and 3 was 7 weeks. During this period each calf was full-fed the next ration to be tested. In trial 1 high-moisture (35% $H_2O$) and regular-moisture (11% $H_2O$) ground ear corn were compared. Each was mixed with Purdue Supplement A in a ratio of 8 to 1 on a dry matter equivalent basis. The digestible energy content of the high-moisture corn-Supplement A ration averaged 72.3% and of the regular-moisture

corn-Supplement A ration was 73.2%. In trial 2 ground corn cobs and soy mill feed were compared as in trial 1. The digestible energy content of the corn cob-Supplement A ration averaged 67.9% and of the soy mill feed Supplement A ration was 73.9%. In trial 3 soy mill feed (11.7% protein) was compared with a mixture of corn cobs and soybean oil meal. The rations were equalized in both protein and dry matter. The digestible energy content of corn cob-soybean oil meal ration was 66.8% and of the soy mill feed was 74.6%.

170. METABOLISM STUDIES OF HIGH-MOISTURE, ENSILED CORN WITH LAMBS. R. K. Mohrman, U. S. Garrigus, E. E. Hatfield, E. W. Dayton and K. M. McKee, *University of Illinois.*

A metabolism trial was conducted with 72 grade lambs to measure nitrogen balance and the apparent digestibility of dry matter, energy, and nitrogen of rations containing shelled corn which was harvested at different stages of maturity and ensiled or dried at different temperatures. The treatments of the corn were a) field dried to 14.5% moisture; b) ensiled at 25% moisture; c) ensiled at 30% moisture; d) ensiled at 35% moisture; e) dried at 140° F.; and, f) dried at 220° F. The ration contained 20 lb. of the test corn and 1.4 lb. of a supplement-roughage mixture containing 32 parts ground dehydrated corncob, 5 parts alfalfa meal, 4 parts molasses, 5 parts soybean meal, and 4 parts complete mineral. The supplement-roughage mixture was fortified with 10 mg. of Aureomycin and 1 gm. of vitamin A and D concentrate per lb. A second metabolism trial was conducted with 36 lambs to compare the nitrogen balances and apparent digestion coefficients of dry matter, energy, and nitrogen of rations containing either field dried corn or high moisture, ensiled corn which was dried to 14.5% moisture. The rations consisted of 50% test corn and 50% of the supplement-roughage mixture which was used in the first metabolism trial. No significant differences among the rations in the first trial were found. In the second trial the average apparent digestion coefficient for dry matter and energy was slightly but non-significantly higher for the ensiled and dried corn. The nitrogen balance was higher ($P<0.05$) for the field dried corn ration.

171. FEEDING VALUE OF HIGH MOISTURE CORN FOR FATTENING LAMBS. C. V. Ross and John C. Rea, *University of Missouri.*

One hundred twenty Idaho feeder lambs were used in a 2 x 2 x 4 factorially designed experiment to compare feeding value and yield of high moisture corn with No. 2 corn, and to observe effects of graded levels of hexestrol implants on gains and carcass characteristics of wether and ewe lambs. One lot of 28 wethers and one lot of 32 ewes were self-fed a complete mixed ration containing ear corn harvested when it had a moisture content of 27% and stored in plastic bags until mixed and fed. Similar groups of 28 wether and 32 ewe lambs were self-fed a ration containing No. 2 corn harvested at a moisture content of 15.5%. Each lot was sub-divided into four uniform groups and implanted with hexestrol. Wethers received implants of 0, 5, 6, and 7 mg. and ewes received implants of 0, 7, 8, and 9 mg. There was no significant difference in gains, grades or yields of lambs fed either high moisture or No. 2 corn in the ration. A savings in lb. of feed required per lb. of gain for the lambs fed the high moisture corn ration of approximately 1.5% was obtained when results were figured on an equivalent moisture basis. Picking the corn wet resulted in a 5–6 bushel higher yield per acre, figured on a dry matter basis, than when harvested later as No. 2 corn. All lambs implanted with hexestrol made significantly faster gains than controls with no significant differences between levels of implantation. Carcass grades and yields were not significantly affected by the treatment. No undesirable side effects were noted in the lambs as a result of implanting with hexestrol.

172. FEEDING AND STORAGE OF HIGH MOISTURE CROPS PRESERVED IN PLASTIC BAGS. R. A. Bloomfield, M. E. Muhrer and C. V. Ross, *University of Missouri.*

Plastic bags made from polyethylene tubing (6 mil. and 50 in. in circumference) were double tied and heat sealed thus forming a handle at each end. Corn silage made and stored for 8 months in the above bags gave values for VFA (% of DM), lactic acid (% of DM) and carotene (mg./lb.) according to the following treatments: Control, 1.51, 4.63, 3.75; 0.4% $Na_2S_2O_5$, 1.51, 5.27, 9.36; 1.0% $Na_2S_2O_5$, 1.46, 1.67, 9.62; and 5% Molasses, 2.86, 5.93, 5.36. These values indicate silage comparable to conventionally stored silage. This silage was highly palatable to cattle, sheep and swine. Stabilized silage made in a conventional silo was also successfully stored in these bags. A 4-week swine feeding trial using 27.5% moisture ground ear corn stored for several months in plastic bags (I) was compared to ground ear corn from the same field allowed to mature to 15.5% moisture (II) and ground shelled corn (III). Rations were all balanced to the same protein content with a protein supplement and pair-fed on a dry weight basis. The average daily gain and feed efficiency were (I) 1.25, 3.22; (II) 1.30, 3.03 and (III) 1.49, 2.67. When allowed to eat *ad lib.* larger animals gave values of (I) 1.56, 4.16; (II) 1.43, 3.93 and (III) 1.65, 3.49. This latter shows the increased palatability due to fermentation.

173. THE SECRETION OF RADIOSTRONTIUM INTO THE MILK OF THE COW AND GOAT: INFLUENCE OF DIETARY LEVELS OF CALCIUM AND STRONTIUM PHOSPHATE. R. H. Wasserman, C. L. Comar and A. R. Twardock, *Cornell University.*

These studies deal with the metabolic behavior of radiocalcium and radiostrontium in the lactating cow and goat, especially the effect of dietary $CaHPO_4$ and $SrHPO_4$ on the secretion of these radionuclides into milk. The experimental animals were maintained on their respective diets for about 21 days prior to receiving two daily doses of $Sr^{89}$ and $Ca^{45}$ by capsule for about 10 days. Radionuclide concentrations in milk, feces, urine, plasma, bone and soft tissues were measured. The cows were given 0.25, 0.50, or 1.3% Ca in their diet, and they secreted, respectively, 0.14, 0.08, and 0.04% of the daily ingested dose of $Sr^{89}$ per liter of milk; the percent daily ingested doses of $Ca^{45}$ secreted per liter of milk for these same groups, were 1.2, 0.8, and 0.4, respectively. In relation to ingested levels, $Sr^{89}$ levels in milk were about one-tenth those of $Ca^{45}$ and this Sr/Ca ratio was independent of dietary treatment. Supplemental $SrHPO_4$ at levels equivalent to the high calcium diet did not appreciably influence the relative behavior of $Sr^{89}$-$Ca^{45}$ in the cow. A similar pattern was observed in the lactating goat with the Sr/Ca ratio between diet and milk also being about 0.1. From theoretical considerations, the constant Sr/Ca ratios in milk on various dietary calcium intakes suggest that, with time, there would be a 1:1 inverse proportionality between dietary calcium and radiostrontium secretion into milk.

174. DIGESTION COEFFICIENTS OF DRIED CELERY TOPS FOR BEEF STEERS. C. E. Haines and H. L. Chapman, Jr., *University of Florida.*

The potential value of dried celery tops as an ingredient of ruminant rations was emphasized by results of a recent steer dry-lot fattening trial. Interest in this feedstuff stimulated the determination of the apparent digestibility of the nutrients therein. Although six two-year-old Devon steers were initially placed on test, only four animals furnished final data for the study. These four steers consumed dried celery tops in amounts sufficient to maintain body weight for preliminary and collection periods of 7 days each. Proximate analysis of the dried celery tops, on a dry matter basis, were 24.8, 22.0, 1.5 and 11.8% for crude protein, fiber, ether extract and ash,

respectively. Dry matter was 82.8%. The average apparent digestibility of the protein, fiber, ether extract and N.F.E. was 77.2, 84.0, 63.4 and 86.1%, respectively. The average digestion coefficient of the dry matter was 79.6.

175. FEEDING VALUE OF DRIED TOMATO PULP AND DRIED CELERY TOPS FOR FATTENING STEERS. H. L. Chapman, Jr. and C. E. Haines, *University of Florida.*

Two feeding experiments, each of 112 days duration, were conducted. In the first one five groups, each of eight yearling steers of an average weight of 490 lb., were fed concentrate mixtures containing 0, 10, 20, 30, and 40% of dehydrated tomato pulp. The steers were allowed the experimental rations *ad lib.* on pasture. Criteria of evaluation included weight gains; feed consumption; intransit shrink; cooler shrink; dressing percent; color, taste and odor of fat and lean tissue; and marbling scores of the *L. dorsi* muscle in the area of the 13th rib. Average daily gains of the five groups were 2.78, 3.06, 2.33, 2.73 and 2.56 lb., respectively. The dehydrated tomato pulp did not affect carcass grades, or lean and fat tissue characteristics. The second experiment involved four groups, each of eight steers of an average weight of 581 lb. Levels of 0, 10, 20 and 30% of dried celery tops were included in the experiment rations. The steers were allowed to eat the experimental rations *ad lib.* in dry lot. The same evaluating criteria were used as in the tomato study. Average daily gains for the four groups were 2.23, 2.28, 1.88, and 2.46 lb., respectively. The dried celery tops did not affect carcass or meat characteristics.

176. RELATIONSHIP OF VARIOUS MEASURES OF PERFORMANCE AND METHODS OF ANALYSES IN CALF NUTRITION STUDIES. J. C. Fortson, W. J. Miller and J. L. Carmon, *University of Georgia.*

Fifty-six dairy calves were used in a 2 x 7 factorial experiment with two factors of hay and seven of starters. Weekly weights, starter consumption, and hay consumption were recorded for 8 consecutive weeks. Treatment effects were significant for gain and the treatment by weeks interaction effects were significant for gain, hay, and starter consumption. Correlations between gain in adjacent weeks were small and non-significant in all cases. These correlations ranged from a low of —.02 for weeks 1 and 2 to a high of 0.24 for weeks 3 and 4. Correlations for starter consumption between adjacent weeks were significant in all cases. The range was 0.57 for weeks 1 and 2 and 0.89 for weeks 6 and 7. The correlations between adjacent weeks in hay consumption were larger than was found with the two previous variables. A correlation of 0.96 was found between weeks 5 and 6 and weeks 6 and 7. Partial correlations were as follows: gain and starter consumption, with hay consumption constant, 0.86; and gain and hay consumption, with starter consumption constant, 0.69. There was a negative correlation between starter and hay consumption. Sire effects were significant for all three variables and were responsible for more of the variation than any of the other sources with the exception of weeks. A more sensitive test is obtained if sire effects are removed from the error.

177. MAGNESIUM STUDIES WITH LAMBS. D. M. McAleese, E. E. Hatfield, and R. M. Forbes, *University of Illinois.*

A description is given of the production and symptoms of magnesium deficiency occurring in two experiments with lambs on a roughage-containing diet. In a third trial, with 21 sheep and 7 levels of magnesium, various criteria for studying magnesium requirement were compared: Blood serum magnesium levels, magnesium balance, growth rate and bone calcium:magnesium ratio. Preliminary observations are consistent with the view that the requirement is not less than 0.06% in the air-dry diet.

178. VOLATILE FATTY ACIDS AS ROUGHAGE SUBSTITUTES FOR SHEEP. H. W. Essig, U. S. Garrigus and B. Connor Johnson, *University of Illinois.*

Twenty-four grade lambs were divided into eight treatments. They were fed purified rations composed of volatile fatty acids (VFA) both as salts and free acids, Drackett protein, sucrose, granulated starch, corn oil, vitamins and minerals. Weight gains and ratios of lb. of feed per lb. of gain were used as criteria of evaluation. Lambs on three treatments (A, E and G) were fed all salts of VFA to supply 24, 30 and 36% total VFA, while three treatments (D, F and H) were fed the above levels plus 6% additional free VFA. The lambs on the two remaining treatments (B and C) were fed VFA rations containing no butyric acid. In addition, the animals on treatment C were defaunated and given 300 mg. of antibiotic mixture daily. The average daily gains for lambs on treatments A, E and G were 0.37, 0.31 and 0.11 lb., respectively. The average daily gains for lambs on treatments D, F and H were 0.11, 0.15 and 0.06 lb., respectively. The average daily gains for lambs on treatments B and C were 0.49 and 0.47 lb., respectively, while their lb. of feed per lb. of gain ratios were 3.67 and 3.53, respectively. Rumen samples were taken by stomach tube for VFA analysis from animals on treatments A, B and C. One molar percent of butyric acid was found in the rumen samples of animals on treatment C as compared to 4.5 and 11.3 molar percent for lambs on treatments A and B. These data indicate that the VFA concentration in the rumen can be controlled by treatment and that butyric acid was not necessary for production of gain.

179. ENERGY REQUIREMENTS OF QUARTER HORSE MARES FOR MAINTENANCE AND WORK. W. W. Albert, *University of Illinois.*

Four pregnant Quarter Horse mares (in 7th and 8th gestation months) and one non-pregnant mare were used in a winter maintenance study. Three mares received bromegrass and alfalfa hays and two received timothy and red clover in weighed amounts daily for 8 weeks to maintain body weight. Seven-day fecal collections were made on individual mares in unbedded stalls with wood block floors. Maintenance was calculated as follows: Maintenance digestible calories = gross energy hay—gross energy feces. Average maintenance in digestible C. per 1000 lb. for pregnant mares was 17430 C. and 17038 C. for the non-pregnant mare. The non-pregnant mare, ridden 4 hours per day, required 17534 additional C. daily per 1000 lb. above maintenance.

180. THE RESPONSE OF RUMINANT ANIMALS TO INGESTED TRANQUILIZER DRUGS. Sam L. Hansard, Neils W. Robinson, A. M. Mullins, P. B. Brown, and G. L. Robertson, *Louisiana State University.*

Response of 50 wether lambs, 40 Hereford steers and heifers and 16 Brahman steers to ingested tranquilizers with and without implanted DES, were studied using conventional and radiochemical procedures. Lambs maintained in 5 lots on high molasses pelleted rations providing daily 5 and 10 mg. stelazine or hydroxyzine, respectively, showed marked weight gain response from both tranquilizers; response was greater at the 5 mg. level and was equivalent to implantation of 3 mg. DES. In combination with DES, tranquilizers gave added 8% boost in daily gains. No significant effect of the drugs was evidenced upon organ weights, Hb, PBI, carcass grade, shrink, DP, cut out values, pH of lean, nor upon liver or muscle glycogen levels in sheep or cattle. Bone growth (mm), measured with Ca-45 in two lambs in each lot, was significantly greater for DES and for tranquilizer treated groups. No sedative or goitrogenic effects were evidenced from thyroid weights or from thyroxine secretion rates even when ingested at levels of 100 mg./day. Results with cattle maintained on a concentrate-grass-hay ration containing 10 mg. trifluoperazine were less conclusive. Although weight gains, feed efficiency and *in vitro* cellulose digestibility values favored

the tranquilizer, data were inconsistent. Response to implanted DES and stelazine did not appear additive in steers as was noted with heifers. Bone growth (mm) in DES treated cattle received the drug during initial 60 days was twice that of lambs, and significantly greater than that of controls receiving DES. Treatment appeared to have no effect on worm egg load.

181. EFFECT OF GAMMA-TOCOPHEROL ON THE INCIDENCE OF TERATOGENY DUE TO MATERNAL VITAMIN E DEFICIENCY. Dorothy Wei Cheng and S. Subbammal, *State University of Iowa.*

Congenital malformations in fetuses were produced experimentally by confining rats to a vitamin E-deficient ration from weaning throughout gestation with the supplementation of a single dose of d,l-alpha-tocopherol acetate on the 10th day of gestation. Approximately 35% of the rats produced abnormal young, 23% yielded one or more normal young while 42% showed complete resorption of the embryos. Comparative studies were made using gamma-tocopherol supplementation instead of the d,l-alpha-tocopherol acetate, which had been used heretofore, in order to see its effect on the incidence of teratogeny. The results indicated that the rats with gamma-tocopherol supplementation gained an average of 32.5 gm. during gestation, significantly less than the 50.9 gm. gained by those rats with d,l-alpha-tocopherol acetate supplementation. At the 1 and 2 mg. levels of supplementation there was a significant decrease in both the normal and abnormal live young with a concomitant increase in the percentage of resorption. The average number of implantation sites was also significantly decreased. When the dosage of gamma-tocopherol supplementation was raised to 4 and 8 mg., there was 100 and 99.3% of resorption respectively. This deleterious effect of higher levels of supplementation of gamma-tocopherol is contrary to the observed beneficial effect of corresponding levels of d,l-alpha-tocopherol acetate.

182. A NEW APPROACH TO THE DESIGN OF A PURIFIED DIET FOR THE BOVINE. R. L. Salsbury, R. W. Luecke and J. A. Hoefer, *Michigan State University.*

183. SUPPLEMENTING LAMB RATIONS WITH OLEANDOMYCIN. R. M. Jordan, *University of Minnesota.*

Oleandomycin was tested as a growth-promoting substance in two fattening lamb trials and one suckling lamb trial. The fattening lambs were full-fed shelled corn and medium quality alfalfa-brome grass hay and soybean oil meal. The oleandomycin was added to the soybean oil meal at a level to provide 5 mg. of oleandomycin per lamb daily in Trial 1 and 10 mg. per lamb daily in Trial 2. In the suckling lamb trial the oleandomycin was mixed in a creep ration which consisted of 9 parts of ground corn and 1 part of soybean oil meal at a level to provide 5 to 7 mg. of oleandomycin per lamb daily. The level of oleandomycin in the creep ration was decreased accordingly as the consumption of the creep feed increased so as to maintain the 5 to 7 mg. level throughout the trial. To minimize the influence of pen location the lambs were switched weekly. Oleandomycin when fed to fattening lambs at a level of 5 mg. per lamb daily had no effect on rate of gain, feed consumption or feed required per lb. of gain. Both groups gained 0.52 lb. per lamb daily. In the second fattening lamb trial, now in progress, lambs fed 10 mg. oleandomycin per lamb daily are gaining more rapidly than the controls (0.63 lb. and 0.52 lb. per lamb daily, respectively). Daily feed consumption is comparable between the two lots. The feed consumption, average daily gain per lamb and feed per lb. of gain of suckling lambs were respectively, as follows: Controls, 0.61 lb., 0.59 lb. and 1.01 lb.; oleandomycin-fed lambs, 0.78 lb., 0.66 lb. and 1.2 lb.

184. SUPPLEMENTS FOR GROWING CATTLE ON SEMI-DESERT RANGES. V. R. Bohman, H. Melendy and M. A. Wade, *University of Nevada.*

During the past 4 years 160 growing cattle have been fed the following supplements on semi-desert range in Southern Nevada: No supplement (controls); 1 lb. barley; 1 lb. soybean meal (SOM); and, 3 lb. alfalfa pellets daily during the winter. In addition, one-half of the cattle in each group were fed 8 gm. of phosphorus daily in the form of bone meal for the entire year. All cattle grazed the same range but were individually fed supplements in portable pens as they came in for water. During the winter all supplements except phosphorus increased the rate of gain above the control animals. Cattle fed protein supplements (SOM and alfalfa) grew significantly faster than those fed the barley-supplement. The rate of gain was equal for the SOM- and alfalfa-supplemented cattle. During the summer, only phosphorus increased the rate of gain but for the entire year both phosphorus and protein supplements resulted in greater gains. Large yearly variations in growth response were observed. Blood analyses were made periodically. The level of circulating erythrocytes was greater when protein supplements were fed. Phosphorus supplements consistently increased the level of plasma phosphorus. Alfalfa, as carotene source, had no effect on the level of plasma carotene or vitamin A. Vitamin A deficiency was not evident during these years. During certain years barley increased the level of plasma carotene while protein supplements tended to lower it. At some intervals phosphorus increased the level of plasma carotene. Seasonal variations in plasma constituents were quite noticeable.

185. EFFECT OF FOUR DRYING TEMPERATURES ON CHEMICAL COMPOSITION OF ALFALFA. W. E. Thomas, M. K. Hathout and John W. Weaver, Jr., *North Carolina State College.*

186. LEVELS OF SUPPLEMENTAL WINTER FEEDING OF BEEF COWS AND CREEP-FEEDING FALL CALVES. R. D. Furr and A. B. Nelson, *Oklahoma Agricultural Experiment Station.*

Fall-calving, mature Hereford cows were divided into four lots and for 4 years were fed different levels of supplemental winter feed while nursing calves. All lots grazed native grass pasture year-long and during the winter were fed either 1.5 lb. of pelleted cottonseed meal or a mixture of 2.5 lb. cottonseed meal and 3 lb. of grain. The calves from one group of cows within each level of wintering were creep-fed. The 4-year average winter weight loss of the mature cows was 36 lb. less for those fed on the high level. Calf weaning weights were increased 30 lb. by the high level of wintering. The calf crop was 85% on the low level and 90% on the high level. Creep-feeding increased weaning weights an average of 87 and 52 lb. for the low and high levels of wintering, respectively. Neither creep-feeding nor the high level of wintering was profitable when prices prevailing during the experiment were considered. Heifers which calved in the fall when they were approximately 2½ years old and fed at a high level of wintering lost 110 lb. less during the winter and produced calves which weighed 46 lb. more at weaning than those fed at the low level. When such heifers (now 3½ years old) were wintered at the two levels during the succeeding winter, the high level of wintering reduced winter losses of the cows 53 lb. and increased weaning weights of the calves 41 lb. However, none of the calves produced by the 2½- and 3½-year-old cows were considered to be of satisfactory size and condition when weaned. Results of wintering trials with yearling heifers and heifer calves indicate that relatively large quantities of supplemental winter feed are necessary to obtain differences in weight gains or losses.

187. EFFECT OF CHLORPROMAZINE ON THE PRODUCTION OF HOLSTEIN COWS UNDER DIFFERENT ENVIRONMENTAL CONDITIONS. M. G. Yang, L. J. Bush, G. V. Odell and G. L. Nelson, *Oklahoma State University*.

Studies were conducted to determine the oral dosage of chlorpromazine required to produce clinical evidence of tranquilization in lactating Holstein cows and to evaluate the effect of daily administration of low levels of the tranquilizer on milk production over a 6-month period. During three different 4-day periods five cows were fed graded levels of chlorpromazine as follows: 50, 100, 150, 200, 250 mg. per day; 300, 350, 400, 450, 500 mg. per day; 1, 2, 3, 4, 5 gm. per day. None of the cows showed clinical evidence of tranquilization and none of the drug could be detected in the milk (lower limit of assay method—.5 p.p.m.). Two cows receiving single oral doses of 4.5 and 9.0 gm. of chlorpromazine, respectively, showed various indications of tranquilization some of which persisted for as long as 24 hours. There was no detectable amount of tranquilizer in the milk from these two cows. Twenty-four cows were used to evaluate the effects of three levels of chlorpromazine on the milk production of cows subjected to different environments. One-half the cows were provided with shelter and pasture while the remainder had pasture only. The tranquilizer was fed daily in two equal portions at the following levels per day: 0, 250, and 500 mg. Grain was allotted to the cows at the beginning of the experiment according to Morrison's standard and was reduced each month thereafter based on the average decline in production of all the cows. No appreciable differences were observed among treatment groups with respect to the production of 4% fat-corrected milk during the 24 weeks of the experiment.

188. EFFECT OF SYSTEMIC GRUBICIDES UPON PERFORMANCE AND GRUB CONTROL IN FATTENING CATTLE. D. L. Staheli, R. H. Hartman and L. H. Horn, *Swift & Company*.

One hundred and fifty Kansas yearling steers were used in an 87-day experiment to determine the effectiveness of systemic grubicides in controlling incidence of grubs in fattening cattle. The cattle were allotted equally to the following three experimental treatments on October 2: Lot 1, control; lot 2, CO-Ral spray (0.5% concentration of a 25% wettable powder applied at the rate of 1 gal. per head at 500 lb. psi); and Lot 3, Trolene bolus (administered at the rate of one bolus per 300 lb. live weight). All cattle were fed the same standard fattening ration of cracked corn, chopped alfalfa hay, molasses and SBOM and were implanted with 36 mg. of diethylstilbestrol. On December 27, when all cattle were dispatched, complete grub counts and carcass data were obtained. The average daily gains of 3.17, 3.16 and 3.12 lb. for the control, spray (Co-Ral) and bolus (Trolene) treated cattle, respectively, showed no statistically significant difference. Neither was there any apparent difference in feed efficiency or carcass quality. There was a highly significant difference between the control and treated lots in effectiveness of grub control. Eighty-nine percent of the control cattle contained five or more grubs per head, whereas only 4% of the cattle treated with the spray or bolus materials were infested with five or more grubs. Average grub counts per steer were 13, 0.9, and 1.2, respectively, for the control, spray, and bolus treated lots.

189. EFFECT OF BUTYLATED-HYDROXY-TOLUENE, DIPHENYL-PARA-PHENYLENEDIAMINE AND OTHER ADDITIVES ON REPRODUCTION AND STEATITIS IN MINK FED FISH DIETS. J. R. Leekley and C. A. Cabell, *USDA, A.R.S. Animal Husbandry Research Division, Beltsville, Maryland, and Experimental Fur Station, Petersburg, Alaska*.

Feeding trials with mink have been conducted for the past five years to evaluate antioxidant additives to diets composed largely of frozen stored fish cannery waste. These trials were designed as factorials using six or eight treatments, starting in the

early part of the breeding season with outcome groups of 12 to 16 female mink. The animals were fed throughout the breeding season and the resulting kits kept on the diets until pelting. In the first two experiments, on diets containing 80% pink salmon waste, the additives used as the treatment variables were an antibiotic, tocopherol and diphenyl-para-phenylenediamine (DPPD), (112 gm. per ton of feed). Reproduction was definitely adversely affected by DPPD. In the second year only 25 females from 48 receiving DPPD produced litters. For the two experiments average kit weaning weights were, for groups fed the antibiotic, 0.815, and, those receiving tocopherol, 0.751, compared to 0.700 lb. for controls. The antioxidant DPPD did prove to be by far the most effective additive for control of steatitis or yellow fat disease. In the third experiment, which was repeated for three years, another antioxidant, butylated-hydroxy-toluene (BHT) was substituted for DPPD. The variables tested were BHT and fish waste from three different fish, red, pink and chum salmon. The high-fat fish, red and pink salmon, resulted in high incidence of steatitis in all experiments when fed without an antioxidant, but BHT successfully controlled the disorder in all groups without producing significantly adverse effects on reproduction.

190. INFLUENCE OF TWO DIETS ON THE HISTOLOGY OF MINK SKIN. Ethel H. Dolnick, *Sheep, Goat and Fur Animal Research Branch, AHRD, ARS, ARC;* Charles F. Bassett, *Sheep, Goat and Fur Animal Research Branch, AHRD, ARS;* Richard G. Warner, *Cornell University.*

To determine whether diets differing radically in quality would result in sufficient changes in the development of the pelt to be detected histologically, 16 growing male minks of the same age, and of the dark strain, average in size and quality, were allotted to two experimental groups. This study of diets differing in protein quality was conducted at Ithaca, N. Y. and Beltsville, Md., during the 1958–59 season. Biopsy samples were taken from the mid-dorsal region of the skin every 4 weeks for the greater part of the experiment and every 2 weeks during the critical periods of hair growth. Animals receiving the low meat ration, group 2, proved to be small in size and the amount of adipose tissue in the skin as well as the total thickness of the skin was less, undoubtedly owing to poor weight gains. The thickness of the epidermis was approximately the same for both groups and the secretory activity of the sebaceous and sweat glands, as well as the development of new hairs from already existing follicles, were comparable for both. However, there were fewer number of hairs produced per follicle bundle in the mink maintained on poor quality protein. The failure of dormant follicles to develop to their full capacity was evidently influenced by the low meat ration diet.

191. A METABOLISM BUILDING FOR LARGE ANIMALS. Lorin E. Harris, John E. Butcher, and Robert J. Raleigh, *Utah State University.*

The metabolism building consists of two stories 42 x 137 feet. There are 9 stalls on the top floor and collection apparatus underneath the floor which can be adjusted for female cattle; and there are 12 metabolism pens for male and female sheep. Space is available for expanding the cattle stalls to a total of 18 for either male or female; for either male or female sheep, to a total of 24 and for four respiration chambers for sheep or cattle. There are 40 pens 4 ft. x 4 ft. with "duck board" bottoms for individually feeding sheep, swine or calves. Service area has stainless steel sinks, space for a garbage disposal unit, feed mixer, deep freeze and refrigerator. Other facilities include small chemical laboratory, feed storage room, large dryer (temperature control from room to 105° C.), sample grinding room (small hammer mill to reduce large samples and Wiley mill), equilibrium room, record room and lavatory. Unique features are flexibility of arrangement, all pens and stalls can be taken down and other apparatus put up in a short time. Floors slope ¼ in. to the foot and all areas can be washed.

192. THE EFFECT OF NUTRITION AND AGE ON THE CARCASS COMPOSITION OF BEEF STEERS. J. P. Fontenot, R. F. Kelly, W. S. Wilkinson, C. M. Kincaid and J. C. Taylor, *Virginia Agricultural Experiment Station.*

In each of two trials 72 steer calves were allotted to four drylot feeding regimens: Lot 1—maintenance ration; Lot 2—full feed of hay; Lot 3—limited amounts of concentrates and full feed of hay; and, Lot 4—full feed of a fattening ration. Groups of steers from each lot were slaughtered about 5, 10, 16 and 23 months after they had been on test. Groups from each lot were placed on pasture about 5 and 17 months after they had been on test and were slaughtered at the end of the grazing season. At slaughter the meat of each wholesale cut from the right side of each carcass was separated from the bone and analyzed chemically. Rate of gain in the drylot-fed steers increased as plane of nutrition increased. In the grazing steers rate of gain during the grazing season decreased as plane of nutrition (and gain) had increased during the drylot feeding period. In the drylot-fed cattle carcass grade, dressing % and percent meat in the carcass were affected ($P<.01$) by nutrition or age. The values increased as plane of nutrition or age increased. Increased plane of nutrition or age significantly increased fat and significantly decreased protein and water content of the meat. Usually, the effect of age on composition and other characteristics of the carcass was not marked at the two lower levels of nutrition (Lots 1 and 2) but was marked in the case of Lots 3 and 4. The feeding regimen x age interaction was significant in all cases except percent meat in the carcass. The results for the grazing steers were similar as for the drylot steers. However, pasture seemed to have an equalizing effect; hence, differences were not so marked among previous drylot feeding treatments.

193. THE EXPRESSION OF GROWTH COMPENSATIONS FOR ENVIRONMENTAL INFLUENCES AFFECTING GAINS OF STEERS. R. C. deBaca, Ralph Bogart, W. A. Sawyer, and Farris Hubbert, Jr., *Oregon State College.*

Weights were obtained at birth, weaning, yearling, and long-yearling ages for 390 steers at the Squaw-Butte Harney Station. Gains in various phases were obtained by difference. Least squares estimates of the effects of year, age of dam, season of birth, age of dam at first calving, and whether or not a cow raised a calf in the previous year were computed. Animals which in one period endured a restriction in growth, owing to any of the environmental influences, tended to compensate for the restrictions in the next period. The compensation for various environmental influences were shown to be measureably independent and intimately related to the amount of deprivation in the previous phase. Compensations are offset in subsequent growth periods through reversed but incomplete compensation. Compensatory growth phenomena obscure genetic potential in post-weaning growth under non-uniform environmental conditions. Age of dam effects at birth were present only in calves from two-year-old cows. A characteristic age-of-dam effect was observed in suckling gains, and was measurable in subsequent gain periods. Season effects were expressed only at birth and in post-weaning phases. There were also compensations for the effects of age of dam at first calving, and whether or not the dam raised a calf in the previous year. The results indicate that in evaluating animals on the basis of gains made in certain phases, cognizance must be taken of differences due to individual environmental criteria which might occasion compensatory growth.

194. THE FERTILITY OF BEEF HEIFERS AFTER ESTROUS CYCLE REGULATION BY INJECTIONS OF OXYTOCIN AND OXYTOCIN PLUS PROGESTERONE. W. Hansel, D. L. Black and R. W. Bratton, *Cornell University.*

Twenty-six of 27 Hereford heifers were brought into estrus within a 7-day period by altering the cycle of each heifer whose heat period did not naturally fall within the

7-day period, by one of two methods. These methods consisted of (a) the production of precocius estrus and ovulation by oxytocin injections during the first 7 days of the estrous cycle, or (b) oxytocin injections during the first 7 days of the cycle and daily progesterone injections concurrent with and for varying periods of time subsequent to the oxytocin injections. All 26 heifers were bred artificially at the estrus occurring during the 7-day period. On rectal palpation approximately 60 days later, 46% of the heifers were found to be pregnant. The lowest conception rate (3 of 13) was found in the heifers bred at the estrus following the oxytocin-plus-progesterone treatment. Six of eight heifers which received no treatment and were bred at a naturally occurring estrus conceived. Two of five heifers conceived when recycled by oxytocin injections and allowed to run one subsequent cycle of normal length before breeding.

195. A NOVEL METHOD FOR ESTIMATING CELL WALL MATERIAL AND LIGNIN IN DEHYDRATED FORAGES. H. P. Binger, C. R. Thompson, and G. O. Kohler, *Western Regional Research Laboratory*.

Proximate analysis is regularly used for feed evaluation because most laboratories are not equipped to carry out animal feeding trials. However, proximate analyses are time-consuming and often yield equivocal results. Complete chemical analysis, which might yield unequivocal results, is unfeasible when large numbers of samples are involved. This dilemma has led to the practice of analyzing for one or more representative components, usually protein, crude fiber or lignin, and using these data to estimate the nutritive value of the feed. Feeding trials have shown good correlations between the nutritive value of a feed and the quantities of these components. During a study of the composition of dehydrated forages, it was noted that a sample's content of lignin and/or total cell wall material could be estimated, indirectly, after a sequence of simple chemical procedures. These involved extraction of the dried sample, first with ethanol-benzene, and then with ammonium oxalate. From dehydrated alfalfa, the residue, when corrected for crude protein, was essentially total cell wall material, and lignin was 20% of this corrected residue. Limited data suggests that other forages may be assayed in the same manner.

196. PASTURE QUALITY AS DETERMINED BY *IN VITRO* AND *IN VIVO* TECHNIQUES. R. L. Reid, D. C. Shelton, J. A. Welch, and G. A. Jung, *West Virginia University*.

Studies with grass hays have established a quantitative relationship between digestion coefficients for dry matter (DM), cellulose, crude fiber, energy, and protein as determined by *in vitro* rumen techniques and by feeding trials. Source of rumen liquor inoculum had a significant effect on *in vitro* digestibility. Further work has indicated the value of the artificial rumen technique in evaluating pasture quality. In one series of feeding trials, digestibility data were obtained on herbage clipped from a bluegrass-orchardgrass and from a timothy-alfalfa pasture at different stages of maturity and fed to groups of fistulated lambs. Concurrent *in vitro* fermentations were run with grass sampled from the pastures and rumen liquor from lambs receiving the grass. Highly significant correlations were obtained between *in vivo* and *in vitro* digestibility of DM, cellulose, fiber, energy and protein. A similar relationship applied to grass samples cut at several growth stages from bluegrass plots maintained under different management and nitrogen-fertilization treatments. The extent of nutrient digestibility *in vitro* varied significantly according to whether the grass was used in the fresh, freeze-dried or oven-dried (65° C.) state, and to whether, in the case of cellulose, the inoculum was obtained from lambs on trial or from fistulated lambs fed a standard grass hay ration. Digestibility *in vivo* was most accurately predicted from

DM digestibility *in vitro* of oven-dried samples. DM digestibility *in vivo* (Y) was related to DM digestibility *in vitro* (X) as expressed in the equation:

$$Y = 20.5 + 0.778X; r = 0.98^{**}$$

197. A SIMPLIFIED ARTIFICIAL RUMEN PROCEDURE FOR ESTIMATING THE DIGESTIBLE ENERGY CONTENT OF HAYS. B. R. Baumgardt, M. W. Taylor, and J. L. Cason, *Rutgers—The State University of New Jersey.*

It has been shown that the digestibility of forage cellulose measured *in vitro* is related to the nutritive value of the forage (J. Animal Sci., 17: 1205, 1958). Studies were made to improve and standardize the artificial rumen procedure for estimating nutritive value. Emphasis was placed on the development of a simple method applicable to routine testing. The factors studied were the type of artificial rumen apparatus, the forage substrate level, the composition of the buffer-mineral solution, the effect of urea additions, the length of fermentation period and day to day variation. A 125 ml. Erlenmeyer flask, initially flushed with $CO_2$ and fitted with a Bunsen valve provided an adequate apparatus for normal fermentations. No dialysis sacs or gassing apparatus was necessary. A one-gram hay substrate level was satisfactory regardless of the cellulose content of the hay. McDougall's artificial saliva (30 ml., full strength) provided a suitable buffer-mineral solution; the pH always remaining above 6.2 in 24-hour fermentations. The addition of urea (0.05%) caused an increased cellulose digestion but lowered the correlation between cellulose digestion *in vitro* and digestible energy *in vivo*. There was no advantage in lengthening the fermentation period from 24 to 48 hours. The efficacy of the improved method was tested with samples of 31 hays of known nutritive value. The correlation between *in vitro* cellulose digestion and *in vivo* digestible energy was highly significant (r=0.854).

198. *IN VITRO* RUMEN FERMENTATION DATA AS INDICES OF EFFECTIVE NUTRITIVE VALUE OF FORAGES. E. Donefer, E. W. Crampton and L. E. Lloyd, *Macdonald College (McGill University) Canada.*

Nine forages, harvested over a period of two years and representing 5 different species (3 legumes, 2 grasses) cut at various stages of maturity and artificially dehydrated, were studied in *in vivo* and *in vitro* tests. *Ad libitum* consumption expressed as a percent of that of an ideal forage (i.e., 80 gm. per $W_{kg}^{.75}$) and digestibility of energy and of other nutrient components were determined in the *in vivo* sheep tests. Cellulose digestion *(in vitro)* was determined at 3, 6, 12, 24, and 48 hours in order to study rate as well as completeness of digestion. Lag periods in the start of cellulose digestion of 2–6 hours were observed between the forages. This differential fermentation start was reflected in the 12-hour cellulose digestion determination, and the latter was found to be highly correlated (r=0.88) with *ad libitum* consumption *in vivo*. After 12 hours differences in initial lag could no longer be identified with species. Only a slight increase in digestion between 24 and 48 hours was found. Cellulose digestion at 24 hours was highly correlated (r=0.87) with *in vivo* energy digestibility. Since effective nutritive value of a forage is a function of both total intake and efficiency of energy utilization, the following hypotheses were tested: 1) that the product of the *ad libitum* intake of a forage and the percent digestibility of its energy, will serve as an Effective Nutritive Value Index of that forage; 2) that the 12-hour and/or the 24 hour *in vitro* cellulose fermentation will serve to predict the Effective Nutritive Value Index.

199. THE USE OF *IN VITRO* RUMEN FERMENTATION DATA. E. W. Crampton, E. Donefer and L. E. Lloyd, *Macdonald College (McGill University) Canada.*

This paper proposes a method of expressing voluntary intake of a specific forage as a percent of the expected intake of an hypothetical "ideal" forage; and the use of this relative intake figure together with the *in vivo* percentage digestibility of energy of

that forage to obtain an Effective Nutritive Value Index for numerically describing forages. It is also tentatively suggested that the Effective Nutritive Value Index (Y) for common legume and grass hays can be predicted from the 12-hour *in vitro* percent cellulose digestion (X) according to the equation:

$$\hat{Y} = \bar{Y} + b\,(X - \bar{X})$$

Our data gives b=1.3 and thus far suggests values of 48 and 44 for $\bar{Y}$ and $\bar{X}$, respectively.

200. CHEMICAL CHANGES PRODUCED BY A CELLULOLYTIC PREPARATION ADDED TO SILAGES. J. M. Leatherwood, R. D. Mochrie and W. E. Thomas, *North Carolina State College*.

(A), first cutting prebloom alfalfa (17.4% DM.), and (B), early-dough stage barley (21.7% DM.) were collected from a field chopper and 6% water with 0.0, 2.5, 5.0 or 10.0 lb./T. of Enzyme 19AP (Rohn and Haas Co.) was added and portions were packed into 2-qt. fruit jars. One jar from each treatment was removed and analyzed after 28d. and 56d. of storage. All silages had good color and odor. The pH of the control was higher than that of those with added enzyme, 4.49 vs. 4.16 for A only. DM. loss as seepage and gas for both silages containing enzyme was 5.35% vs. 0.51% for the controls. Enzyme treatment resulted in significantly lower cellulose content, the effect being greater in A than in B. On the 10 lb./T. level with A, 20% hydrolysis of cellulose occurred at 56d., based on the control. Less reducing substances were found in enzyme treated A than B. In both A and B significant hydrolysis of cellulose and formation of end-products occurred at 28d and additional amounts were noted at 56d. Most of the cellulolytic activity of the enzyme remained at 56d.

201. EFFECTS OF DATE AND METHOD OF HARVESTING OF MIXED HAY ON THE PERFORMANCE OF FATTENING LAMBS. J. R. Jones, D. E. Hogue and G. L. Hunt, *Cornell University*.

Two hundred sixty-four western whiteface feeder lambs were randomly assigned to a 3 x 2 factorial experiment with 4 lots of 11 lambs on each of the 6 treatment groups for a 91-day period. The variables included three dates: Early cut (EC), May 31; Late cut (LC), July 7; and Second (SC), August 4, 1958, and two methods, heat dried (HD) and field cured (FC), of harvesting of mixed hay. The hays were fed free choice, weighbacks determining the amounts eaten. Grain was fed at the rate of 1.25% of bodyweight per day. Significant differences ($P<0.01$) were detected between the three dates of cutting for daily gain, final liveweight grade and hay consumption. Curing methods affected only the grade. The average daily gain (lb.), final liveweight grade (choice = 10, Good = 7, etc.) and average daily hay consumption (lb.) of the treatment groups were, respectively, EC-HD, 0.43, 8.8, 2.30; EC-FC, 0.41, 8.3, 2.23; LC-HD, 0.27, 5.8, 1.87; LC-FC, 0.25, 5.2, 1.79; SC-HD, 0.36, 7.5, 2.09; SC-FC, 0.38, 7.1, 2.11. The percent digestible dry matter of the hays were EC-HD, 69.3; EC-FC, 65.4; LC-HD, 55.8; LC-FC, 51.8; FC-HD, 60.8; SC-FC, 62.2. Thus, the early cut hay was superior to the late and second cut hays in all criteria measured and the second cut superior to the late cut. In every case lambs fed heat dried hay graded slightly above lambs fed field cured hays. Differences in consumption and digestibility of the hays can explain most of the differences in gain of the lambs.

202. RELATIONSHIP BETWEEN APPARENT BODYWEIGHT LOSS, DROP IN RUMEN FILL AND FECAL EXCRETION OF CATTLE TURNED TO PASTURE. L. D. Brown, R. S. Emery, D. E. Morgan and E. J. Benne, *Michigan State University*.

Four dry, rumen fistulated Holstein cows were fed 20 lb. of full bloom timothy hay per day for 15 days after which they were immediately changed to green chopped

alfalfa in amounts to supply approximately the same level of dry matter. Samples of feces and urine were collected for 5 days during the hay feeding period and 14 days during the alfalfa feeding period. Each animal was weighed on each of three days prior to and daily during the feeding of green chopped alfalfa. The average apparent loss in bodyweight was 52.2 lb. per cow which occurred approximately 8 days after changing to fresh forage. The total reticulo-rumen losses average 52.7 lb. which contained 7.3 lb. dry matter. The increased fecal dry matter excretion for the same period averaged 5.0 lb. per cow. This increase, however, was due mainly to one cow which had limited water ingestion and thus decreased dry matter consumption and fecal excretion prior to the alfalfa feeding. The apparent dry matter digestibility of the timothy hay was 61.9% as compared to 69.6% for the fresh forage which resulted in 0.9 lb. less undigestible residue ingestion per day from the fresh forage. In general, the apparent loss in body weight was accounted for by a corresponding decrease in reticulo-rumen fill resulting from a combination of increased fecal passage and increased digestibility of the green forage.

203. THE NUTRITIVE VALUE OF COASTAL BERMUDAGRASS HAY FOR BEEF CATTLE AS AFFECTED BY RATE OF NITROGEN FERTILIZATION, MATURITY, AND PELLETING. R. A. Alexander, J. F. Hentges, Jr., J. T. McCall, H. W. Lundy, N. Gammon and W. G. Blue, *Florida Agricultural Experiment Station.*

In two 4 x 4 digestion trials and two winter feeding trials, yearling heifers were used to study the nutritive value of coastal bermudagrass hays from the following treatments: 50 lb. nitrogen/acre baled before frost (BF50) and after frost (AF50); 100 lb. nitrogen/acre baled before frost (BF100) and after frost (AF100). These hays, plus a mineral supplement, fed as wintering rations were adequate for reproduction as measured by frequency of estrus, ovulation, and pregnancy diagnosis. Blood analyses showed no significant differences between treatments. Significant weight losses occurred in heifers fed (AF50) hays. Protein content was significantly lower in hays cut after frost and with lower nitrogen applications. In the feeding trials the average protein content of hays (%), daily gain (lb.) and hay consumption (lb.), were as follows: Trial I, group fed, (BF100) 8.2, 0.7, 17.2; (AF100) 6.1, 0.4, 16.9; (BF50) 6.2, 0.6, 16.5; and (AF50) 4.6, —.7, 12.7. Trial II, individually fed, (BF100) 8.9, 0.4, 15.1; (AF100) 7.6, 0.2, 15.6; (BF50) 7.4, 0.2, 15.5; and (AF50) 6.2, —.3, 12.5. Digestibility of protein was significantly lower ($P<0.01$) in (AF50) hays. Digestible energy and TDN values were similar within and between treatments. Hay fertilized with 200 lb. nitrogen/acre was fed long and pelleted. Protein content (%), and digestion coefficients (%) were: Pelleted 15.2, 69, and long 13.3, 70, respectively. Calories/lb. and digestion coefficients were: Pelleted 2034, 52, and long 2191, 60, respectively. Digestible energy was slightly lower in the pelleted hay.

204. ANIMAL PERFORMANCE, TEMPERATURE CHANGES AND PRESERVATION LOSSES WITH RYE GRASS AND CRIMSON CLOVER VS. SUDAN SILAGES. W. J. Miller, H. L. Dalton and J. K. Miller, *The University of Georgia.*

Silos 1 and 2 were filled with Tift Sudan in the pre-boot and the boot stages, respectively. Immature Italian rye grass (58%) and crimson clover (41%) were used in two other silos 3 and 4. Silo 3 was filled in 6 hours with packing. One week and no packing were used for silo 4. The percentage dry matter content of the forages was 12.8, 16.4, 12.2, and 13.1 for silos 1–4, respectively. Seepage and total dry matter losses in percent were 8.1, 26.5; 2.2, 16.3; 14.5, 22.1; and 12.5, 27.4, respectively. The highest temperatures recorded, based on the average of several points for the four silages, were 93, 99, 88, and 90° F. The silages were fed as the only roughage to 23 dairy cows in a

continuous experiment. Persistency percentages of milk production on a 5½ week basis were 85, 81, 95, and 89 for silages 1–4, respectively. Corresponding silage dry matter consumption and body weight gains were 14.0, —.4; 14.4, 0.2; 17.0, 1.4; and 14.4, 0.1 lb. per cow per day. The differences in milk production, silage consumption and weight gains were statistically significant. These experiments indicate that the temperature was not greatly affected by filling a silo slowly; however, dry matter losses increased and milk production, voluntary feed consumption, and weight gains were reduced.

205. ESTROGENIC ACTIVITY IN DEHYDRATED AND SUNCURED FORAGES. E. M. Bickoff, A. L. Livingston, A. N. Booth, A. P. Hendrickson, and G. O. Kohler, *Western Regional Research Laboratory.*

A large number of dehydrated forage samples were obtained from various parts of this country and surveyed for apparent estrogen content. Also included were a number of suncured alfalfa, clover, and grass samples. Very large variations in apparent estrogen content were found between samples. These may be partially attributed to differences in geographical location, variety, cultural practice, stage of growth, or season of year at which plants were harvested. Other factors shown to be involved are losses of estrogen during dehydration or subsequent environment of the meal. A very important factor appears to be the presence in meals of estrogen potentiators and/or inhibitors in varying proportions.

206. A NEW TECHNIQUE FOR SECURING MILK PRODUCTION DATA FOR BEEF COWS NURSING CALVES IN NUTRITION STUDIES. W. Brady Anthony, Paul F. Parks, E. L. Mayton, L. V. Brown, J. G. Starling and T. B. Patterson, *Alabama Agricultural Experiment Station.*

Except for the noteworthy report by Gifford (J. Animal Sci., 8:605, 1949), little factual information has been published on the milk production of beef cows. The procedure that is reported here permits direct measurement of milk secretion and composition, and is as follows: The cow is separated from her calf and put in a break where she is injected (intramuscular) with 2 cc. of oxytocin (40 U.S.P. units). The udder is washed with warm water and teat cups of a portable De Laval milking machine are attached. Immediately after starting the milker, the hour and the cow's number are recorded. By careful stripping, most cows are milked out in 5 minutes. This first milking is a pretest milk-out and need not be weighed or sampled. The cow remains separated from her calf overnight, but is supplied feed and water. She is returned to the break about 12 hours later for the test milking. Oxytocin is administered in the same way as described for the pretest. The udder is washed, the milker attached and the hour recorded. Hand stripping must be patiently performed. The total production is weighed and a sample taken for butterfat analysis. Production is reported on a 12-hour, FCM basis. The technique has been extensively tested and used routinely with large numbers of cattle.

207. EFFECT OF ADDING SOYBEAN OIL TO GREEN-CHOPPED ALFALFA ON MILK PRODUCTION, MILK COMPOSITION AND OTHER RESPONSES OF DAIRY COWS. C. F. Foreman, N. L. Jacobson, D. K. Hotchkiss and A. R. Porter, *Iowa State University.*

Previous work at this station has shown that feeding 0.5 lb. soybean oil per animal daily as a bloat preventive in the grain allowance of steers grazing alfalfa pasture markedly increased weight gains. Also, it has been shown that sprinkling soybean oil over green-chopped forage is an effective means of preventing bloat. Therefore, the present experiment was designed to determine whether soybean oil fed to lactating

cows would affect milk production or milk composition. Twenty Holstein and Brown Swiss cows were divided into two comparable groups and were allowed to eat green-chopped alfalfa *ad libitum* for a 4-week period. Concentrate was fed in accordance with milk production. One group received 0.5 lb. of soybean oil per cow daily sprinkled over the fresh forage. Average pre-experimental pounds of milk daily per cow, percent total solids and percent fat were 49.3, 11.2 and 3.1, respectively, for the control group and 50.0, 11.4 and 3.3, respectively, for the soybean oil group. Similar measurements during the 4-week experimental period were 50.1, 11.3 and 3.0 for the controls and 51.1, 11.3 and 3.1 for the treated group. During a 2-week, post-experimental period the controls produced slightly more milk. Daily forage consumption per 1000 lb. body weight was essentially the same for the two groups (approximately 127 lb. as fed; 24 lb. DM.). After adjustments for body weight there were no appreciable differences in efficiency of conversion of feed to milk between groups.

208. NUTRIENT ADDITIONS TO GREEN FORAGES IN THE PRODUCTION OF BLOAT IN LAMBS. Donald Warner, Walter Woods and Wise Burroughs, *Iowa State University*.

Different nutrient materials were added to alfalfa soilage and alfalfa pasture in studying factors contributing to incidence and severity of bloat. Urea and sugar solutions sprinkled on chopped forage just prior to feeding increased the incidence of bloat slightly. No affect was observed by including potassium or phosphorus in the added solutions. In another series of trials a glucose solution sprinkled on fresh clipped alfalfa slightly increased bloat incidence. However, bloat frequency was not affected by additions of egg-white or phosphorus solutions or by combinations of these materials with glucose. Also drenching alfalfa soilage-fed lambs with solutions of glucose and/or egg-white had no appreciable effect on incidence of bloat. Foliar spray applications to alfalfa grazing plots significantly influenced incidences of bloat. In 11 four-day grazing periods, urea and/or glucose solutions sprayed on growing alfalfa increased both frequency and severity of bloat. In lambs blood ammonia nitrogen and non-protein nitrogen were higher when forage was treated with urea. However, there were no consistent agreements between blood nitrogen compounds and severity of bloat observed.

209. A COMPARISON OF TALL FESCUE AND ORCHARDGRASS WHEN GRAZED BY YEARLING BEEF STEERS AND HEIFERS. R. C. Peterson, G. O. Mott, M. E. Heath, and W. M. Beeson, *Purdue University*.

A two by two by three factorial design was employed to compare fescue and orchardgrass, with and without "sod seeded" cereal at 0, 75 and 150 lb. of nitrogen per acre. All pastures received 200 lb. of 5–20–20 fertilizer. The nitrogen was applied as a split application. Comparative criteria include average daily gain, number of animal days per acre, beef production per acre, botanical composition of each pasture treatment and chemical composition of the herbage. The pastures were grazed rotationally. The 1958 grazing season extended from April 29 until November 24. The cattle which grazed the orchardgrass pastures displayed greater average daily gains than did the fescue group; however, the fescue had a greater carrying capacity so that slightly more beef was produced on fescue than on orchardgrass. Under the conditions of this experiment no additional beef was produced by "sod seeding" dual wheat in the respective cool season grass sods. During the first 139 days of the grazing season (April 29 to Sept. 15) the average daily gain of the cattle grazing orchardgrass pastures tended to increase with the additional application of nitrogen, however this trend was reversed for fescue. The number of animal days per acre increased appreciably with additional nitrogen increments on all of the pasture combinations.

210. INFLUENCE OF NITROGEN ON BOTANICAL COMPOSITION AND BEEF-RETURNS FROM FESCUE-LADINO AND ORCHARDGRASS PASTURES. H. R. Duncan, C. S. Hobbs, E. J. Chapman, J. B. McLaren and L. M. Safley, *University of Tennessee.*

In a trial at Highland Rim Experiment Station yearling steers weighing 650 lb. were grazed for 4 consecutive summers on pastures seeded to fescue and Ladino clover. One pasture received no nitrogen, the other had five 50-lb. applications of ammonium nitrate applied at 60-day intervals. The unnitrated pasture had 52% clover the first year, as determined by 11 bi-weekly estimates, and 38% the fourth year; the other 42% and 5% clover, respectively. The daily gains for 144 days respectively were 1.27 and 1.11 lb.; the grazing days per acre, 158 and 191; the beef gains per acre, 207 and 235; slaughter value, $17.76 and $15.95 cwt., and the returns over nitrogen costs per acre on cattle appraised $20.50 in the spring, $16.07 and —$4.43. At MTES fescue-orchardgrass-alfalfa-white clover pastures grazed from Nov. 1 to Sept. 1 without nitrogen, with 30 lb. N in spring and 30 lb. N applied both in spring and fall were compared with orchardgrass-alfalfa-white clover spring nitrated. Nitrating fescue-clover pastures increased the fescue to 77% and reduced the clover to 10%. The spring nitrated orchard-grass-white clover pastures had 44% orchardgrass and 44% clover the third year, which are desirable amounts. The daily gain during the summer was 62% greater on the orchardgrass-white clover pasture than on nitrated fescue-orchardgrass-white clover pastures. The steers on the nitrated fescue pastures had rough coats, lacked finish, and were appraised $2.23 per cwt. lower than the nitrated-orchardgrass-white clover steers, and the acre return was $29.87 less.

211. APPETITE STUDIES IN DAIRY CATTLE: GRASS SILAGE VS. HAY. D. Hillman, C. A. Lassiter, C. F. Huffman, and C. W. Duncan, *Michigan State University.*

Twenty-five lactating Holstein cows were used in a 90-day trial to determine the effects of all silage, all hay, and hay-silage combinations on dry matter intake, milk production, and body weight. The alfalfa hay and silage were both harvested from the same field at the same stage of maturity. Five balanced groups were fed one of the following rations on a dry matter basis without grain: All silage, 25% hay-75% silage, 50% hay-50% silage, 75% hay-25% silage and all hay. Silage was eaten *ad lib.* and hay was controlled except in the all-hay ration. Average daily dry matter intake, DM. per 100 lb. body weight, FCM, and total body weight change per cow, respectively, for the rations were, all silage, 26.2 lb., 2.44 lb., 26.6 lb., and —58 lb.; 75% sil.-25% hay, 28.6, 2.70, 26.1 and —20 lb.; 50% hay-50% sil., 32.8, 2.97, 29.2, and —5 bl.; 75% hay-25% sil., 35.1, 2.99, 31.0 and +51 lb.; all hay, 41.0, 3.52, 30.7 and +23 lb. DM. intake per 100 lb. body weight was significantly greater for cows fed all hay or 75% hay than for cows fed all silage, or 25% hay ($P<.01$). Intake on the all hay, 75% hay, and 50% hay rations was significantly greater ($P<.05$) than on the 25% hay plus silage or all silage rations. Milk production was significantly greater ($P<.01$) on the all hay, 75% hay, and 50% hay rations than on all silage or 75% silage rations. The silage was direct cut, preserved with sodium metabisulfite and it averaged 25% DM. Its average pH was 4.48.

212. EFFICIENCY OF PHENOTHIAZINE, PIPERAZINE, COPPER SULPHATE AND NICOTINE SULPHATE IN THE CONTROL OF HAEMONCHUS IN SHEEP ON PASTURE. P. E. Loggins, L. E. Swanson, D. D. Cox, J. T. McCall, M. Koger and D. D. Hargrove, *University of Florida.*

Ninety ewes of Hampshire, Rambouillet and Native breeding were divided into three equal treatment groups. Group 1 served as a control; Group 2 received 25 gm.

phenothiazine N.F. (William Cooper & Nephews, Inc.) alternated with 4 fluid ounces of copper sulphate-nicotine sulphate (Cunic); and, Group 3 received a combination of 25 gm. phenothiazine and 7.1 gm. anhydrous piperazine "Dowzene" (Dow Chemical Co.). The treated groups were drenched at 56-day intervals. Ewe weights in the treated groups were significantly heavier ($P<0.05$). Hemoglobin levels among the groups were not significantly different. Breed differences in hemoglobin and weight were significant ($P<0.05$ and $P<0.1$, respectively). Fifty-one lambs were divided into a control and a phenothiazine group, "Phenovis" (Imperial Chemical Industry), and treated at 28-day intervals. Treatment differences in weight gains, hemoglobin levels and death losses were not significant. Breed differences in hemoglobin levels were significant ($P<0.01$). Fecal cultures from 32 lambs showed that "Phenovis" reduced the number of *Haemonchus* larvae developing in the feces to zero for 2 days after treatment and greatly reduced the total larvae during this period. However, both *Haemonchus* and total larvae were increasing by the third day post treatment. Although larval development was greatly suppressed, the adult *H. contortus* infection was not reduced by treatment with "Phenovis".

213. COMPARISON OF PHENOTHIAZINE VERSUS COPPER SULPHATE FOR CONTROL OF PARASITES IN LAMBS ON PASTURE. C. V. Ross and R. L. Pavey, *University of Missouri.*

Phenothiazine and copper sulphate were compared for control of internal parasites. Treatments were as follows: One lot received 1 1/3 oz. of 40% phenothiazine drench initially and phenothiazine salt mixture (1:9) *ad lib.;* the other lot was drenched with 1½ oz. of a 2% copper sulphate solution initially and at four-week intervals, plus iodized salt *ad lib.* A second drench of phenothiazine and of copper sulphate was required in one of the tests at six weeks owing to heavy worm infestations. Each lot of lambs grazed similar lespedeza pastures throughout the trial. Worm egg counts were made periodically. In trial A all lambs were thrifty and had low worm egg counts. Lambs on phenothiazine gained 0.283 lb. per head daily compared to 0.259 lb. for those treated with copper sulphate, and they graded slightly higher alive at the end of the trial. Worm egg counts were somewhat higher from lambs drenched with copper sulphate. Initial worm infestations were much higher in lambs used in Trial B and they remained slightly higher throughout the experiment. The phenothiazine lot gained 0.153 lb. per head daily versus 0.095 lb. for lambs treated with copper sulphate. Lambs treated with phenothiazine also appeared thriftier and graded higher alive at the end of the trial than those on copper sulphate. Low egg counts at the end of the trial indicated that both systems of internal parasite control were effective in controlling worms. Gains and finish were in favor of lambs on phenothiazine but differences were not statistically significant.

214. SOME EFFECTS OF TRANQUILIZER AND DIETHYLSTILBESTROL ALONE AND IN COMBINATION ON GROWING-FINISHING CATTLE ON WINTER TEMPORARY PASTURE. D. M. Baird, H. C. McCampbell and O. E. Sell, *Georgia Experiment Station.*

Two trials were conducted to observe the response of cattle to tranquilizer feeding when the cattle were stilbestrol implanted and grazed on a winter temporary pasture mixture of oats, ryegrass and crimson clover. Drylot-fed cattle served as the control each year. High grade yearling Herefords were allotted on a basis of weight, sex, sire and feeder grade and grazed for 155 and 109 days the first and second years, respectively, at a stocking rate of approximately 1.6 animals per acre. Two mg. hydroxyzine were fed per head daily to the grazing cattle in 4–6 lb. of grain. Detailed carcass observations were made. Approximately 10 animals were fed per lot. Treatments and ADG (lb.) for the first test were (1) drylot 1.96; (2) pasture only 1.46; (3) pasture

+ grain 1.65; (4) 3 + 24 mg. stilbestrol implant 1.59; (5) 4 + hydroxyzine 1.70. Pastures were severely damaged by a mid-winter freeze which reduced all pasture gains. Drylot gains and carcass grades were significantly higher (P, 1%) than the pasture gains with no significant treatment differences on pasture. All cattle received a 24-mg. stilbestrol implant the second year with treatments and ADG (lb.) was as follows: (1) drylot 2.14; (2) pasture + grain 2.47 (3) 2 + hydroxyzine 2.28 (4) 3 + 36 mg. oxytetracycline daily 2.44. Lot 2 gained significantly (P, 5%) faster than lot 1 with no significant differences between pasture lots. No carcass grade differences occurred between treatments. In these tests tranquilizer failed to improve cattle gains or carcass grades when fed to stilbestrol implanted cattle grazing winter temporary pasture.

215. PROTEIN SUPPLEMENTS FOR WINTERING EWES ON PASTURE AND ROUGHAGE. R. L. Pavey, C. V. Ross and A. J. Dyer, *University of Missouri.*

Approximately 60 northwestern ewes were used each of three years in wintering experiments with late lambing ewes. Strong thrifty lambs were produced by ewes pastured on bluegrass until early January then allowed corn silage *ad lib.* plus protein supplement in dry lot until lambing. In two of the trials in which ewes were fed 0.33 lb. soybean oil meal per head daily they made significantly (P=.05) greater gains during pregnancy, produced 0.4 to 0.5 lb. heavier fleeces, and gave birth to slightly heavier lambs which weighed approximately 4 lb. more at weaning than similar ewes receiving 0.13 to 0.14 lb. soybean oil meal. A repeat of the first trial with ewes reversed on treatments gave essentially the same results. In the third trial, ewes were again wintered until January 1 on permanent pasture then fed corn silage in dry lot. Soybean oil meal was fed at a rate of 0.35 lb. per ewe daily in one lot. A similar lot was allowed corn silage *ad lib.* plus equivalent amount of protein and energy furnished by alfalfa hay and shelled corn. Lambs from both lots were strong and healthy. Fleece weights were 0.35 lb. heavier from ewes receiving alfalfa hay and corn, but ewes receiving 0.35 lb. soybean oil meal gained significantly (P=.05) more during pregnancy and gave birth to 1.1 lb. heavier lambs (significant, P=.05, for singles). Digestibility of the corn silage was 35%.

216. EFFECT OF HORMONES ON METABOLISM. J. D. Alexander and William Medway, *University of Pennsylvania.*

217. LIVEWEIGHT GAIN STIMULATION IN BEEF CATTLE WITH METHIMAZOLE ADMINISTRATION WITH OBSERVATIONS UPON GROWTH HORMONE SECRETION. Allen Trenkle and Wise Burroughs, *Iowa State University.*

Eight cattle feeding trials comprising 270 cattle were conducted to study the effects of feeding 600 mg. of methimazole (Tapazole) per animal per day for short feeding periods ranging from 35 to 56 days. The feeding of methimazole increased daily liveweight gain in each experiment by an average of 15% or 0.4 lb. per animal per day. Approximately this amount of increased gain occurred irrespective of whether the methimazole was fed at the beginning or the end of the fattening trial, whether steers or heifers were fed or whether or not stilbestrol was included in the ration. Methimazole feeding had little or no influence on daily feed consumption. However, feed conversion was improved in each of the eight experiments by an average of 15%. Carcass data were obtained in five of the eight experiments. These results indicated that the addition of methimazole to the ration during the latter part of the feeding period had no influence on dressing percent but had a tendency to improve federal carcass grade. Growth hormone secretion was measured in four lots of cattle based on assays of the anterior pituitary at the time of slaughter.

218. EXCRETORY PATHWAYS AND TISSUE RESIDUE STUDIES OF 2-$C^{14}$ LABELED METHIMAZOLE. Ned S. Raun and Wise Burroughs, *Iowa State University*.

Excretory paths and possible tissue deposits of 2-$C^{14}$ methimazole (Tapazole) were determined in rats following the oral administration of this compound in daily doses equivalent to 0.5 mg. per lb. of body weight. Following the oral administration of a single dose of 2-$C^{14}$ methimazole, rats were placed in a special metabolism cage in determining the excretory paths of labeled metabolites via the feces urine and expired $CO_2$. Recovery of the administered isotope ranged between 89–109%. Of the recovered activity, an average of 81.9% appeared in the urine, 18.1% in the feces, with no activity appearing in the expired $CO_2$. Ninety-five percent of the activity recovered in the urine appeared during the first 24 hours after dosage while only 19% of the total activity recovered in the feces appeared during this same period. No appreciable activity was found in the urine and feces 96 hours after dosing. Tissue residue studies were conducted using rats that received oral daily doses of 2-$C^{14}$ methimazole for periods ranging between 7 and 14 days. These rats were sacrificed 4 days after administration of the isotope was discontinued. Increasing the length of the dosage period did not produce a significant buildup of labeled metabolites in the various tissues. If 2-$C^{14}$ methimazole or methimazole metabolites were present in the dried tissues, results of these assays indicate that it would be in quantities of less than 1 ppm.

219. RESPONSE OF GROWING-FATTENING LAMBS TO GRADED LEVELS OF HEXESTROL IMPLANTS. C. V. Ross, John C. Rea, R. L. Pavey, *University of Missouri*.

Subcutaneous implants of hexestrol in wether and ewe lambs resulted in significantly ($P<.01$) faster gains (average of 18% for wethers and 30% for ewes) and more efficient gains (11.3% for wethers and 21% for ewes) than controls in five experiments with 368 lambs. When levels of implants were within the range of 5–7 mg. for wethers and 7–9 mg. for ewes, no undesirable side effects were observed and carcasses of lambs treated with hexestrol graded as high as controls. Carcass yields averaged approximately 1.2% lower for lambs treated with hexestrol, but the differences were not statistically significant.

220. SOME PHYSIOLOGICAL RESPONSES OF THE BOVINE TO EPINEPHRINE ADMINISTRATION. K. A. Kendall and K. E. Harshbarger, *University of Illinois*.

Following the subcutaneous administration of 30 to 40 ml. of epinephrine (1:1000) to non-lactating dairy cows, blood serum calcium levels were elevated as much as 0.5 mg. % and to a maximum of 1.5 mg. % within 6 to 9 hours over the preinjection levels. Serum inorganic phosphorus levels declined from 5.3 mg % to 3.6 mg. % during the same period. The concentration of urinary calcium was increased two to three times that of the initial concentration, while the urinary inorganic phosphorus concentration was approximately doubled during the same period. Blood sugar levels were increased two to three times or even higher. The rates of urinary excretion of reducing sugar were increased to three or more times those of the preinjection level. The intravenous injection of 5 ml. of epinephrine (1:1000) was followed 10 minutes later, by a 0.5 mg. % drop in serum calcium, while serum inorganic phosphorus concentration declined 0.56 mg. % within 3 hours after injection. The blood sugar level following the intravenous injection of 5 ml. of epinephrine (1:1000) was more than doubled within 10 minutes. The heart rate was doubled within 6 hours following subcutaneous injections, while the average respiration rate increased from 27 to 45 respirations per minute. Body temperatures remained constant.

221. PHYSIOLOGIC EFFECTS OF RESERPINE ON EWE LAMBS. A. D. Allen and A. W. Uren, *University of Missouri.*

Forty western ewe lambs divided into lots of 10 were fed for 14 weeks. Lot I was a control lot. Reserpine was added to the remaining lots at the following levels per lb. of feed: Lot II, 0.0625 mg.; Lot III, 0.125 mg.; and Lot IV, 0.25 mg. A pelleted ration containing 60% ground corn, 35% alfalfa meal, and 5% soybean oil meal was hand fed twice daily. Terramycin was added at a level of 10 gm. per ton. Weights and blood samples were taken at weekly intervals. A lamb from each group was slaughtered weekly beginning on the fourth week. Dressing percentage and grade were determined. Adrenals, ovaries, thyroid, pituitary, thymus, and mammary glands were obtained at slaughter, gross weights determined and glands sectioned for later study. A significant difference between lots was found in gross weights of thyroids while gross weight of the thymus approached significance. Blood samples were analysed for packed cell volume, hemoglobin, white blood cell count and blood glucose levels. Analysis of variance technique indicated a significant difference between lots only in blood glucose levels. No significant differences were noted between different lots in rate of gain, dressing percentage and carcass grades of animals. Feed consumption and efficiency of feed conversion were not influenced by the addition of this ataractic.

222. THE TOXIC EFFECTS OF STABLE STRONTIUM IN THE DIET OF SWINE (A FILM). J. C. Bartley and E. F. Reber, *University of Illinois.*

In experiment 1, group 1 pigs (4) were fed the control ration containing 0.5% calcium and group 2 pigs (5) were fed a ration in which strontium replaced calcium. In experiment 2, there were 3 pigs per group. Group C was fed the control ration containing 0.7% calcium. Group S was fed a ration in which strontium replaced calcium. Group CS ration contained calcium and strontium. Group O ration contained neither calcium nor strontium. The pigs were on experiment from 3 to 8 weeks of age. Incoordination followed by posterior paralysis was observed in group S pigs. Group CS pigs and group O pigs occasionally showed incoordination and weakness in the hind limbs. All pigs fed strontium either with or without calcium and group O pigs showed signs of rickets. In experiment 1 the mean weight gain of the control pigs (0.48 lb./day) was significantly greater than pigs fed strontium (0.36 lb./day). In experiment 2 all groups gained an average of 0.35 lb./day, except group S (0.25 lb./day). In experiment 1 no significant difference due to treatment occurred in the percentage ash (33) of femora. The average percentages of ash of femora in experiment 2 were 42, 35, 43 and 37 for groups C, S, CS, and O, respectively. The average percentages of calcium of the femoral ash were 34, 28, 31, 27, 27 and 30 for groups 1, 2, C, S, CS and O, respectively. In groups 2, S and CS strontium was 6–7% of femoral ash.

223. ESTRUAL ACTIVITY IN OPEN RAMBOUILLET EWES. Hal B. Barker and Earl L. Wiggins, *Alabama Agricultural Experiment Station.*

Open Rambouillet ewes were checked twice daily for estrus for a 2-year period. The monthly variation in number of ewes exhibiting estrus within each year was significant. The peak of 95.5% sexual activity in this group of open ewes occurred in November 1957, whereas a similar peak of 94.5% occurred in October 1958. A low level of 50% sexual activity occurred in April of the first year, whereas a low of 33% was observed in July of the second year. Twenty ewes in 1957 and 12 ewes in 1958 had exhibited estrual activity between the beginning of the breeding season (May 19) and late June. In both years there was a similar progressive decline in number of ewes having heats during the late winter and early spring months. Anestrus occurred in 18 of 23 ewes, varying in its beginning from February through April. The average length of this anestrus was 84.6 days. Cycle lengths of approximately 17 days or multiples

of this constituted approximately 93% of the intervals between heats. Eighty-six % of these estrual periods were classified as singles with the remaining 14% as multiples. The 2-year average for length of estrus in open-Rambouillet ewes was 2.5 checks. The checks were approximately 12 hours apart. The monthly difference in length of estrus was not significant for either year.

224. A COMPARISON OF FOUR DIFFERENT METHODS FOR DETECTING ESTRUS AND OVARIAN ACTIVITY IN HEREFORD AND BRAHMAN HEIFERS. J. R. Howes, A. C. Warnick and J. F. Hentges, Jr., *University of Florida.*

Twelve Hereford and 12 Brahman registered, virgin heifers were allocated at random into two treatments, 100% and 50% of the N.R.C. recommended protein allowances, respectively. These animals were individually fed and housed except for a daily 10-hour period when they were in dry-lot. During two 63-day periods (October 22-December 23, April 20-June 21) these animals were observed twice daily for signs of estrus. Each morning they were checked for vaginal temperature (*J. Dairy Sci. 41:* 1071) and vaginal smears (*J. Animal Sci. 17: 322.*) They were palpated rectally by the same person each week for the presence of follicles and corpora lutea, as a standard for evaluating the other three methods. During both periods, 74 corpora lutea were detected. Thirty-two observations of heat, 61 positive vaginal smears and 62 characteristic vaginal temperature changes coincided with corpora lutea. Simultaneously, 1 heat observation, 12 positive smears and 79 vaginal temperature changes could not be associated with ovarian activity. There was a close relationship between vaginal and ambient temperature particularly in the Brahmans during cold weather. There was a highly significant difference in the occurrence of corpora lutea between two species, two seasons and their interaction. The level of dietary protein appeared to have no influence on these criteria. Brahmans exhibited anestrus in the winter. Although not as reliable as rectal palpation, the vaginal smear technique was the best of the other methods.

225. THE CONTROL OF ESTRUS AND OVULATION IN GILTS BY ORALLY ACTIVE PROGESTATIONAL COMPOUNDS. John E. Nellor, *Michigan State University.*

The progestational action of 17$\alpha$-acetoxyprogesterone and 17$\alpha$-hydroxy-6$\alpha$-methylprogesterone was determined after oral administration to mature gilts. Complete inhibition of estrous activity and follicular growth was not obtained by once-a-day feeding of 17$\alpha$-acetoxyprogesterone. Once- or twice-a-day feeding of 17$\alpha$-hydroxy-6$\alpha$-methylprogesterone resulted in complete inhibition of estrous activity and follicular growth regardless of the stage of the estrous cycle when treatment started. Estrus occurred, on the average, 4.2 days after the end of a 24-day treatment period, the gilts coming into estrus within a 36-hour period. Ovulation at the controlled estrus, as determined at autopsy 3–4 days from the start of estrus was normal. There were no detrimental effects upon subsequent estrus or ovulation when gilts received twice the amount of 17$\alpha$-hydroxy-6$\alpha$-methylprogesterone necessary to completely inhibit follicular growth. The control of estrus and ovulation in domestic animals by the administration of orally effective progestational compounds represents a minimal insult to management and animal welfare.

226. THE EFFECT OF LEVEL AND SEQUENCE OF FEEDING AND BREED ON OVULATION RATE, EMBRYO SURVIVAL, AND FETAL WEIGHT IN THE MATURE EWE. R. A. Bellows, A. L. Pope, A. B. Chapman and L. E. Casida, *University of Wisconsin.*

Eighty Hampshire and 88 Columbia mature ewes were randomly assigned to four prebreeding feed regimes differing in number of days grain was fed in addition

to hay—0, 18, 39 or 60 days. After breeding each group was subdivided into hay only (H) or hay + grain (H + G) until 140 days of gestation. The breeding plan produced straightbred and reciprocal crossbred fetuses in each final group. Percent multiple ovulations: Hampshire 70%, Columbia 48% ($P<0.01$); H + G before breeding 64%; H, 44% ($P\cong0.09$). Postbreeding feed level survival percentages: H, 84; H + G, 69 ($P\cong0.07$). The postbreeding feed level X breed of sire interaction showed survival of Hampshire sired fetuses lower on H + G during gestation than on H and less than Columbia sired on either ($P\cong0.08$). Crossbred fetuses carried by Columbia dams on H + G showed poorer survival than on H and poorer than crossbreds carried by Hampshire dams on either feed ($P\cong0.08$). Postbreeding feed level effects on fetus weight: H, 10.2; H + G, 11.7 lb. ($P<0.01$). Hampshire dams produced heavier fetuses than Columbia dams (11.3 vs. 10.6 lb. $P<0.02$). The interaction of postbreeding feed level X "breeding" of the fetus showed straightbred fetuses responding more to H + G compared to H, during gestation than crossbreds ($P\cong0.06$). Hampshire dams afforded maternal environment superior to Columbias on postbreeding H but this tended to reverse on H + G ($P\cong0.06$). In both Hampshire and Columbia ewes grain feeding before breeding tended to produce heavier crossbred than straightbred fetuses ($P\cong0.07$). Prebreeding H + G gave better maternal environment than H in Columbia dams as indicated by fetus weights but the reverse occurred in Hampshired Dams ($P\cong0.07$).

227. GENETIC AND ENVIRONMENTAL INFLUENCES ON PREGNANCY RATE IN BEEF CATTLE. J. H. Meade, Jr., A. C. Warnick, M. Koger and W. L. Reynolds, *University of Florida.*

The rate of pregnancy in 10,170 beef cattle was determined during the five-year period from 1953 through 1957. Eighteen locations including both experiment stations and private ranches were used. Pregnancy was diagnosed by rectal palpation at 3 months or more after the end of the breeding season. Cattle of British, Brahman, Santa Gertrudis, Brangus, British x Native, Brahman x Native and Brahman x British breeding were included. Age of dam and lactation status were grouped as non-lactating 2-year-old heifers, non-lactating 3-year-old cows, lactating 3-year-old cows, non-lactating cows 4-years-old or older, and lactating cows 4-years-old or older. Adjusted pregnancy rates were obtained by the method of least squares. The overall unadjusted pregnancy rate was 70.9%; the overall adjusted rate was 64.8%. Adjusted pregnancy rates in percent in the various breed groups were, British, 72.6; Brahman, 56.8; Santa Gertrudis, 57.4; Brangus, 65.2; British x Native, 77.2; Brahman x Native, 59.9 and Brahman x British, 64.6. The adjusted pregnancy rates in percent for age of dam and lactation status were, non-lactating 2-year-old heifers, 62.6; non-lactating 3-year-old cows, 69.7; lactating 3-year-old cows, 43.6; non-lactating cows 4-years old or older, 89.0; and lactating cows 4-years-old or older, 59.1. The range in pregnancy rate of the 18 locations was from 41.8 to 82.8%. The range in pregnancy rate of the 5 years was from 58.7 to 73.5%. Significant differences were obtained among breeds, ages and lactation status, and locations.

228. THE EFFECT OF SINGLE DOSES OF PROGESTERONE ON THE LIVABILITY OF SWINE EMBRYOS. W. F. Davis, Jr. and A. M. Sorensen, Jr., *Texas Agricultural Experiment Station.*

Sixty-seven gilts were used in two trials to study the effect of progesterone on embryonic survival. One group of animals served as a control, and the remaining animals were given intramuscular injections of progesterone at one of three levels, 250 mg., 625 mg. or 1250 mg. One-half of the gilts on each level was injected at the time of breeding (day zero) and the other was injected 7 days after breeding (day seven). The animals were checked daily for heat and were bred as soon as they would accept the male. On the 40th day of gestation the gilts were slaughtered and embryonic

survival was determined. This study indicated a beneficial response to progesterone when administered on the seventh day after breeding. The more favorable response was noted in the group receiving 625 mg. on day 7 in which the percent survival was 13.39% greater than the control group. There were several indications that progesterone at the level of 1250 mg. had an adverse effect. In the group receiving 1250 mg. on day zero only three out of ten animals were pregnant and their embryonic survival was only 25%. In the group receiving 1250 mg. on day seven the embryonic survival was 62.96% but in this group only five out of nine animals were pregnant. Six incidences of cystic follicles were observed, five of which occurred at the 1250 mg. level of progesterone injection and one at the 625 mg. level.

229. THE INFLUENCE OF AMBIENT TEMPERATURE ON EARLY PREGNANCY LOSS AS DETERMINED BY EMBRYO TRANSFER. C. W. Alliston and L. C. Ulberg, *North Carolina Agricultural Experiment Station.*

Thirty-three embryos from 42 donor yearling ewes were transferred into 27 recipient ewes. Estrus in donor and recipient ewes was synchronized to within 24 hours either naturally or with the aid of hormones. Five days before predicted estrus, all ewes were randomly allotted to and placed in environmental chambers maintained at 70 or 90° F. with approximately 65% relative humidity. Donors were bred on the subsequent estrus to rams producing high quality semen. The transfers were then performed 72–84 hours later. Only embryos judged to be in a "normal" stage of development were transferred. Recipient ewes were kept in the designated chamber until return to estrus or a laporatomy was performed 25–30 days after transfer. The higher environmental temperature caused a significant increase in the rectal temperature (104.4° F. vs. 103.0° F.) and respiration rate (136/min. vs. 66/min.). Thirty-four corpora lutea with 24 transferable embryos were observed in 26 donor ewes kept at 70° F. as compared to 22 corpora lutea with 9 transferable embryos in 16 ewes kept at 90° F. When both donor and recipient were maintained at 70° F., 5 of 11 transferred embryos resulted in pregnancies as compared with 6 of 13 when donor and recipient were maintained at 70 and 90° F., respectively. No pregnancies resulted from 9 transfers in which donor and recipient were held at temperatures of 90 and 70° F., respectively.

230. THE EFFECT OF NORETHYNODREL AND ETHYNYLESTRADIOL 3-METHYL ETHER ON REPRODUCTION IN THE GILT. L. L. Anderson and R. M. Melampy, *Iowa State University.*

A group of 15 gilts was injected intramuscularly with a mixture of norethynodrel and ethynylestradiol 3-methyl ether (Enovid) in sesame oil. Treatment was started on the 17th day of the estrous cycle and continued for 8 days. Various levels (2, 5, 15 and 25 mg. per 100 lb. body weight) were used and a delay in estrus was observed with all except at the 2 mg. level. The 5, 15 and 25 mg. levels were effective in delaying estrus 8–10 days after the last day of treatment. The animals were bred at this estrus and slaughtered 25 days later. The average embryonic survival was 68% (range 8–100%). In a second group of gilts, the material was administered orally in corn oil starting at various stages of the estrous cycle (day 1, 5, 7, 12 and 17) and continuing to a constant day, treating 24, 20, 18, 13 and 8 days, respectively. This group consisted of 33 crossbred gilts and were treated with levels of 1, 2, 3, 4, 7.5 and 15 mg. per 100 lb. body weight. The lowest level failed to inhibit estrus during treatment whereas the 2 and 3 mg. levels resulted in a variable time of estrus. The 4 mg. level gave the most uniform response, estrus occurring 2–5 days in seven animals and 12 and 20 days in the case of two animals after the end of treatment. Levels of 7.5 and 15 mg. caused a slightly longer delay of 7–10 days. Their estrous behavior was normal; however, some difficulty was encountered in maintaining pregnancy. Four gilts on the 4 mg. level

did not conceive when bred at the adjusted estrus whereas five gilts on this same level had an average embryonic survival of 72% on the 25th day of gestation.

231. THE EFFECTS OF ORALLY ADMINISTERED DIETHYLSTILBESTROL ON REPRODUCTION IN FEMALE MINK. R. L. Cochrane, R. K. Meyer and R. M. Shackelford, *University of Wisconsin.*

Thirteen yearling female mink were each given 5 ug. of diethylstilbestrol per day orally from July 20 through the day of autopsy approximately 1 year later; another group of 15 yearling mink served as controls. The females were all exposed to males during their breeding season (March), and the reproductive performance of the two groups was compared. At autopsy body, adrenal, ovarian and pituitary weights of the diethylstilbestrol fed females were compared with those from the controls. Eight pituitary glands from each group were collected and divided into four lots of two glands each. Each lot was assayed on one male and one female immature rat, using ovary, seminal vesicle, ventral prostate and testicle weights as indicators of quantities and kinds of gonadotrophin. No significant differences were found in average number of kits born, born alive, or alive at 7 days when the calculations were based on all females, or only those that had whelped. The ovarian weights of the estrogen treated females, however, were markedly reduced ($P<0.01$). There were no significant differences in body, pituitary or adrenal weights. The rats receiving pituitary homogenates from the diethylstilbestrol treated mink had smaller ovaries ($P<0.01$), testis ($P<0.02$) and seminal vesicles ($P<0.05$) than the control rats, while the ventral prostates were not significantly smaller. These results suggest that estrogen caused a reduction in the gonadotrophin of the mink pituitary glands.

232. BIOCHEMICAL STUDIES OF THE BOVINE CORPUS LUTEUM OF EARLY PREGNANCY. R. G. Zimbelman, R. G. Loy and L. E. Casida, *University of Wisconsin.*

Corpora lutea from heifers with normal embryos at 14 days (14P), 28 days (28P), or 42 days (42P) of pregnancy were studied. In addition a group of non-bred heifers were studied on day-14 of the estrual cycle (14C). The average corpus luteum weights (14C—5.78, 14P—5.64, 28P—5.26, 42P—5.48 gm.) were not significantly different. RNA contents showed a trend for decreasing amounts with increasing length of pregnancy, the concentration in the 42-day group was lower ($P<.05$) than that of the other three groups (14C—5.43, 14P—5.27, 28P—5.04, 42P—4.46 mg. per gm. wet tissue). DNA concentrations did not differ. Concentrations of progesterone did not differ between the 14-day groups (14C—31.4, 14P—35.2 $\mu$g. per gm.), but both were significantly higher ($P<.01$) than the concentrations at the two later stages (28P—18.0, 42P—9.9 $\mu$g. per gm.). Another steroid, probably $\Delta^4$ pregnene-20$\beta$01-3 one as reported by others, was present at somewhat lower levels. The latter steroid showed a tendency for slight increase during the periods of pregnancy studied (14P—5.9, 28P—8.0, 42P—9.1 $\mu$g. per gm.). Total cholesterol values were highest at day-28 of pregnancy, being significantly ($P<.05$) higher in that stage than in the other 3 stages which did not differ from each other (14C—2.21, 14P—2.53, 28P—2.92, 42P—2.56 mg. per gm.).

233. *IN VITRO* PROGESTERONE SYNTHESIS BY SWINE CORPORA LUTEA. G. W. Duncan and R. M. Melampy, *Iowa State University.*

During a two-hour *in vitro* incubation period, swine luteal tissue is capable of synthesizing progesterone in amounts up to six times its initial concentration. Corpora lutea slices, suspended in Krebs-Ringer-Bicarbonate medium containing glucose, were incubated for 2 hours at 37.5° C. with 95% oxygen—5% carbon dioxide in a Dubnoff metabolic shaking incubator. Following incubation the samples were homogenized in

95% ethanol. Progesterone was then isolated and quantitatively estimated by a method based upon 95% ethanol extraction, column adsorption chromatography, countercurrent distribution, paper chromatography and ultraviolet absorption spectrophotometry. Preliminary data indicate initial and post-incubation progesterone concentrations (mcg. per gm.) of corpora from gilts 4, 8, 12, 16 and 18 days post-estrus are, respectively, 20, 133; 39, 116; 65, 137; 76, 165; and 0, 0. For gilts pregnant 16, 24, 48 and 72 days the concentrations are 81, 113; 83, 153; 103, 142 and 76, 145. Intramuscular administration of LTH (125 and 250 I.U. per day) for 3 days prior to slaughter or *in vitro* (10 to 200 I.U.) during incubation has not altered progesterone synthesis under these conditions. Homogenized gilt pituitary tissue added during incubation has had no affect on synthesis. Pregnenolone (100 to 250 mcg.) included in the medium increased progesterone synthesis proportional to the amount added.

234. THE LEUKOTAXIC EFFECT OF EXUDATES FROM RABBIT UTERI. H. W. Hawk, G. D. Turner and J. F. Sykes, *Dairy Cattle Research Branch, Animal Husbandry Research Division, ARS.*

The leukocytic response to bacteria occurs more quickly in estrous than pseudopregnant rabbit uteri. Since this could be due to a differential production or release of leukotaxic substances, a comparison was made of the properties of estrous and pseudopregnant rabbit uterine exudates with regard to increasing capillary permeability and inducing diapedesis of leukocytes. The uterine horns of estrous and pseudopregnant rabbits were flushed with small amounts of sterile saline 1, 2 and 4 hours after inoculation with *Escherichia coli*. Cells were removed by centrifugation; 0.1 ml. of each exudate was injected into the abdominal skin of another rabbit and the recipient rabbit given 60 mg. of trypan blue intravenously. After 2 hours the skin around each injection site was removed for histological study. Uteri of estrous exudate donor rabbits were infiltrated more heavily at each time interval than were uteri of pseudopregnant exudate donors. However, exudates from pseudopregnant rabbits were consistently more effective than estrous rabbit exudates in inducing leukocytic infiltration of tissue around the skin injection sites and in increasing capillary permeability, as measured by the intensity of blue coloration at the injection sites. Flushings from unoperated pseudopregnant rabbit uteri were also somewhat leukotaxic; those from unoperated estrous rabbits were not. The differential leukocytic response of estrous and pseudopregnant rabbit uteri during the early stages of induced infection is apparently due to factors other than a relative lack of leukotaxic substances in pseudopregnant rabbit uteri.

235. HISTOLOGICAL AND CYTOLOGICAL CHANGES IN THE BOVINE UTERINE EPITHELIUM. G. B. Marion and H. T. Gier, *Kansas State University.*

Uteri from 200 clinically normal dairy cows representing specific stages of the estrous cycle, gestation and postpartum were utilized in this study. The uterine epithelium consists of a layer of pseudostratified columnar cells resting on a "basement membrane" consisting of a compressed layer of stratum compactum cells. Height of the epithelium varies considerably during all stages of the cycle. Osmiophilic and $PAS^+$ granules are more concentrated in the basal part and exhibit no apparent cyclic variation. Fusion of the serosal ectoderm and uterine epithelium begins at approximately 18 days gestation and is characterized by a progressive loss of osmiophilic and $PAS^+$ granules from the epithelial cells and an increase of such granules in the trophoblast. The epithelial cells became vacuolated and are progressively destroyed over both caruncular and intercaruncular surfaces until the serosa is in contact with the outer cell layer of the stratum compactum which becomes reoriented into a cuboidal connecting layer. This oriented cell layer persists in placentomes, however intercaruncu-

larly a new epithelium originates from uterine glands and fetal contact is lost. Secondary erosion of the new epithelium may occur during the formation of accessory placentomes. Following parturition, the intercaruncular epithelium may be eroded by bacterial lysis, but is normally repaired by 20 days postpartum. After the caruncular mass has sloughed, epithelial cells migrating from the surrounding uterine glands have normally covered the surface of the caruncle by 30 days postpartum.

236. WATER AND ELECTROLYTE CONCENTRATIONS IN COW UTERI DURING EARLY PREGNANCY. Joel Bitman, Helene Cecil, H. W. Hawk, J. Bond and J. F. Sykes, *Dairy and Beef Cattle Research Branches, Animal Husbandry Research Division ARS.*

A study was made of the variation between 13 cow uteri in $H_2O$, Na and K concentrations during the first 4 months of pregnancy. In the endometrium, $H_2O$ and Na concentrations tended to decrease and K concentrations to increase as pregnancy progressed through 4 months. Seven cows were pregnant between 17 and 57 days and six cows between 71 and 121 days. Mean endometrial values for these 2 groups were as follows: $H_2O$, 86.5 and 85.4% ($P<0.05$); Na, 92.8 and 79.0 mM/Kg. wet tissue ($P<0.01$); K, 38.5 and 51.3 mM/Kg. wet tissue ($P<0.01$). In the myometrium, the relative water concentrations were reversed for the 2 groups, being 82.7 and 84.5% ($P<0.01$) for the 17–57 and 71–121 day groups, respectively. Values for Na and K were not significantly different between the two groups, being 77.7 and 69.6 mM/Kg. wet tissue for Na and 52.8 and 58.8 mM/Kg. for K.

237. THE USE OF ADENINE-8-$C^{14}$ FOR STUDYING SPERMATOGENESIS IN THE RABBIT. R. H. Foote and H. H. Koefoed-Johnsen, *Cornell University, and The Royal Veterinary and Agricultural College, Denmark.*

Three bucks were injected with adenine-8-$C^{14}$ into the cava vaginalis to explore the time required for sperm formation and transport in the rabbit. Pilot studies with $P^{32}$ showed that the uptake of radioactive material by the testes was increased by this method of local administration. Radioactivity was detected in blood taken from the ear vein 10 minutes post-injection, reaching a peak 2 to 3 days later, and then gradually declining. Two ejaculates of semen were taken every third day and pooled. Radioactivity measurements were made on whole semen, seminal plasma, 3x washed spermatozoa, and deoxyribonucleic acid (DNA), chemically isolated from the sperm. Quantitative estimates of the DNA present were made by determining the phosphorus content of the DNA fraction. Whole semen and seminal plasma showed considerable radioactivity 3 to 6 days after injection, but this declined to a low level by 30 days post-injection. The 3x washed sperm showed little radioactivity, and the sperm-DNA showed no radioactivity above background until 42 days post-injection. The specific radioactivity of the sperm DNA rose rapidly to a peak of 45 counts per minute per $\mu$g. DNA-P 54 days post-injection, and fell to 7.7 counts per minute on the day of sacrifice, 66 days after injection. Positive autoradiographs of epididymal sperm were obtained 32 days post-injection. Rabbit spermatozoa were estimated to contain between $2.8 \times 10^{-9}$ and $3.5 \times 10^{-9}$ mg. DNA per spermatozoan. The correlation coefficient between the number of spermatozoa per ml. of semen and the amount of DNA isolated from aliquots of this semen was $+0.98$, $P<0.01$.

238. VIABILITY, GROWTH AND SEXUAL DEVELOPMENT IN PRENATALLY IRRADIATED SWINE. H. B. Pace and R. L. Murphree, *UT-AEC Agricultural Research Laboratory.*

Eight pregnant gilts were exposed to 400 r, total body irradiation, from cobalt-60 between the 54th and 64th day of gestation. Eight gilts of comparable age and breeding

served as controls. The average litter size at birth was 11.9 and 11.0 for the control and irradiated litters, respectively. Differences between the two groups of pigs in birth weight, weaning weight and viability to weaning were not significant. The average testes weights of control and irradiated boars castrated at 120, 203 and 254 days of age were 46, 532, 720, and 32, 370, 528 gm., respectively. Beginning at 120 days of age, control and irradiated boars were given four opportunities to serve an estrous gilt. Twenty-five of 28 control and 7 of 10 irradiated boars served the gilt for an average service rate during all trials of 63% and 55%, respectively. Five control and six prenatally irradiated boars were used in semen studies. Semen was collected in the artificial vagina twice weekly for six periods and daily for six periods. The control boars significantly exceeded the irradiated boars in semen volume and total sperm per ejaculate. There were no differences between the two groups in concentration, per cent motile sperm or degree of motility, per cent abnormal sperm, per cent live sperm, oxygen utilization per ml. of semen or per billion sperm.

239. EFFECTS OF TOTAL BODY IRRADIATION ON SEMEN PRODUCTION OF BOARS. H. B. Pace, R. L. Murphree and E. W. Hupp, *University of Tennessee-Atomic Energy Commission Agricultural Research Laboratory.*

Fifteen boars were used in a study of the effects of acute total body irradiation on semen production during a 7-month postirradiation period. At 10 months of age five boars received 200 r and five boars received 400 r gamma irradiation from cobalt-60; five boars served as controls. There was no evidence of a radiation effect on sperm production during the first 3 weeks postirradiation. The percent of abnormal sperm increased the 4th week, rose to a high the 7th through 9th week and then declined. The percent live sperm decreased slightly the 4th through 6th week. Oxygen utilization, measured in the Warburg constant volume respirometer, decreased during the 5th and 6th week following irradiation. After the 5th week sperm numbers decreased from an average of 50 billion to less than 10 billion in the 200 r group and less than 1 billion sperm per weekly ejaculate in the 400 r group during the 9th week. This decrease was followed by a rapid increase so that the preirradiation average sperm production was exceeded by the 13th week. However, the total sperm production per weekly ejaculate had not reached the level of the controls by the 25th week after irradiation. Beginning at the 26th week daily ejaculates were obtained for 14 days. With the exception of one boar, in the 400 r group, there were no differences between groups in sperm production during this period.

240. SEMEN CHARACTERISTICS AND SEXUAL BEHAVIOR IN THE BOAR FOLLOWING ADMINISTRATION OF ATROPINE. P. J. Dziuk, *University of Illinois.*

Various drugs which influence the autonomic system were administered during a study on the mechanism of sperm transport in the male. The possible role of the parasympathetic system in the ejaculation process and sperm transport was tested by injecting atropine sulfate subcutaneously in boars. Three boars 2, 2, and 4 years old (385–500 lb.) trained to mount a dummy and serve an artificial vagina, were the experimental animals. Atropine was given at levels of 8.1, 16.2 or 32.4 mg. per boar in 4 cc. of saline in a single site behind one ear. No restraint was used during injection. Semen collection was started 30 minutes after injection. Collections were made at 4-day intervals and injections were made at 12-day intervals. Collections made on days of no injections served as controls. Atropine given at the levels mentioned had no marked affect on the behavior of the boar towards the dummy, behavior during the collection nor the time required for ejaculation. The average volume of the liquid semen collected after treatment was about 16% of the normal volume. The average total number of sperm per ejaculate following treatments was slightly higher than

normal. The average concentration of sperm in liquid semen was 1,226 x $10^6$ per cc. (462–2,280 x $10^6$) following treatment and normally was 253 x $10^6$ per cc. (59–930 x $10^6$). There was a marked reduction in the amount of accessory secretions in the semen. The dose level of atropine usually had an inverse affect on the ejaculate volume and total number of sperm. Weight of the boar seemed to influence the dose-effect relationship.

241. THE FERTILITY OF FROZEN AND UNFROZEN RAM SEMEN. N. L. First, A. Sevinge and H. A. Henneman, *Michigan State University*.

In the first trial each of 10 ewes were cervically inseminated with 213 million sperm in one ml. of milk-diluted, thawed frozen ram semen and each of 10 control ewes were inseminated with 600 million sperm in 0.2 ml. of undiluted ram semen. Thirty percent of the ewes inseminated with thawed frozen semen conceived as compared to 60% of the control ewes. In a second trial, none of 47 ewes conceived when cervically inseminated with 100 million sperm in 1 ml. or 0.5 ml. ram semen diluted in heated homogenized milk, yolk citrate or Ukranian diluters. The average motility one week after freezing was 70%. Forty-six ewes were cervically inseminated with semen diluted and stored less than 2 days. The percent conception with the different diluters was, yolk citrate, 21.4%; milk, 46.7%; and Ukranian, 17.7%. The differences in conception rate between diluters or between volumes of semen inseminated were not significant.

In a third trial, 32 ewe lambs were cervically inseminated with the milk diluted semen of two Hampshire rams. No difference in conception rates occurred between ewes inseminated once during estrus and those inseminated at 12-hour intervals throughout estrus. Twelve and one-half percent of the ewes inseminated conceived in each case. No difference in conception rate occurred between ewes mated to a vasectomized ram before insemination and ewes that were not. Again, 12.5% conceived in each case.

242. THE MOTILITY DECLINE OF FROZEN RAM SEMEN DURING PROLONGED —79° STORAGE AND THE EFFECT OF GLYCEROL EQUILIBRATION ON MOTILITY OF THAWED FROZEN RAM SEMEN INCUBATED AT 39° AND 5° C. N. L. First, H. A. Henneman and W. T. Magee, *Michigan State University*.

One ejaculate from each of two Hampshire rams was diluted 1:200 in heated homogenized milk diluter and frozen. Four vials from each ejaculate were periodically thawed over a period of 14 months to determine the rate at which frozen ram sperm lost motility during —79° C. storage. Motility decline was the most rapid during the first 2 months of storage, there being very little change thereafter.

A 2 x 2 x 2 factorial experiment involving pooled ejaculates of two Hampshire rams in two trials was used to study the motility decline of frozen and unfrozen ram semen equilibrated with glycerol for 1 and 18 hours and incubated at 39° and 5° C.

After 8 hours, sperm motility was 5% and 60% for incubation at 39° C. and 5° C., respectively. No difference in motility existed between 1 and 18 hours of glycerol equilibration. No difference in motility existed between unfrozen and thawed frozen samples. Motility of over 50% was maintained by unfrozen and thawed frozen samples incubated for 240 hours at 5° C.

243. THE ADDITION OF EGG YOLK TO A MILK DILUTER AND ITS EFFECT ON GLYCEROL REQUIREMENT FOR FREEZING RAM SEMEN. N. L. First, H. A. Henneman and W. T. Magee, *Michigan State University*.

A factorial experiment involving the pooled ejaculates of two rams in two trials was utilized to determine if added egg yolk at levels of 0, 3, 6, 12 or 24% would

improve freezing survival of milk diluted ram sperm and secondly to determine what combination of egg yolk and glycerol levels of 6, 9, 12 and 15% might result in the greatest sperm survival after freezing. Samples were cooled 3° C. per minute to —15° C. and frozen at 5° C. per minute to increase the possibilities of temperature shock and thus create a critical condition to evaluate the treatment. An analysis of the percent survival 1 week after freezing indicated no significant improvement in sperm survival from 3, 6, 12 or 24% egg yolk addition. At glycerol levels of 6, 9, 12 and 15%, the mean percent sperm survival was 65, 66, 25 and 1, respectively. Percent sperm survival was significantly greater ($P<0.01$) at glycerol levels of 6 and 9%. A significant interaction ($P<0.01$) occurred between the effect of egg yolk and glycerol levels on ram sperm motility after freezing.

244. LACTIC DEHYDROGENASE ACTIVITY IN BOVINE SEMEN. O T. Stallcup and J. S. Hayden, *Arkansas Agricultural Experiment Station.*

Lactic dehydrogenase (LD) activity has been determined in 43 samples of bovine semen from 23 bulls of the Aberdeen-Angus, Holstein-Friesian, Guernsey, Jersey and Milking Shorthorn breeds. The mean activity value expressed as Berger-Broida units/ml. of bovine semen was 2026 with a standard deviation of 151 units. The correlation coefficient between LD units/ml. of semen and 30–60 day non-return conception data was —.414 ($P=0.01$). The correlation coefficient between LD units/billion spermatozoa and 30–60 day non-return conception data was —.071 (not significant). The correlation coefficient between LD units/ml. and volume of semen/ejaculate was 0.131 and the correlation coefficient between LD units/ml. and % motility at time of ejaculation was 0.050. These correlations were not significant. Observations on 15 semen samples indicate that most of the LD activity in bovine semen is associated with the seminal plasma.

245. EFFECT OF METHOD OF COLLECTION ON QUALITY OF BULL SEMEN. J. W. Austin, E. W. Hupp and R. L. Murphree, *UT-AEC Agricultural Research Laboratory.*

Semen was collected in an artificial vagina (AV) or by electro-ejaculation (EE), using the finger electrode method, from 12 Hereford bulls during a 12-week period. The only criterion for inclusion of a bull in the group was that he would serve the AV. An attempt was made to obtain two successive ejaculates from each bull on 2 days each week. A total of 248 of a possible 287 ejaculates were obtained in the AV and 287 ejaculates were obtained by EE. The average values for semen collected in the AV and by EE were: Sperm per ml. (x $10^6$), 610 and 295; sperm per ejaculate (x $10^6$) 1684 and 1826; volume (ml.), 2.7 and 6.3; pH, 6.7 and 7.2; and motility, 2.2 and 2.6, respectively. Samples obtained on 8 of the collection days were stored in egg yolk-citrate diluent at 5° C. for 4 days. Immediately after dilution to approximately 12 million sperm per ml. 68% of the AV samples and 94% of the EE samples had a minimum motility rating of 2. At the end of the 4-day storage period 28% of the AV samples and 70% of the EE samples had a minimum motility rating of 1.5. These results indicate that semen obtained by this electro-ejaculation technique is comparable in quality to semen obtained in the artificial vagina.

246. A COMPARISON OF NATURAL MATING WITH ARTIFICIAL INSEMINATION AND THE INFLUENCE OF VOLUME AND SPERM NUMBERS ON CONCEPTION RATE AND FERTILITY LEVELS IN SOWS. F. W. Stratman and H. L. Self, *University of Wisconsin.*

Sixty sows of mixed breeding, having exhibited at least one pre-experimental estrous cycle, were randomly assigned to four treatment groups and bred on the

second day of the experimental estrous period either by natural service or artificially with semen from one of three boars. Group I sows were bred by natural service and served as the control group. Group II sows were inseminated with 2.5 x $10^9$ sperm in 50 ml. of milk diluent (Thacker and Almquist, 1951) containing 1000 mcg. dihydrostreptomycin sulfate per ml. Group III sows were inseminated with 2.5 x $10^9$ sperm in 100 ml. of diluent and Group IV sows were inseminated with 1.25 x $10^9$ sperm in 100 ml. of diluent. The mean percent conception rate for the four groups was 53.3, 80.0, 80.0, and 53.3, respectively. The mean number of corpora lutea was 16.4, 15.5, 17.5 and 16.2 for the four groups, respectively. The mean percent of the corpora lutea represented by embryos at the 25th day of gestation in all sows in Group I was 31.7; Group II had 57.2; Group III had 60.5; and Group IV had 35.8. The mean number of pigs per litter for all sows at the 25th day of gestation was 5.2, 9.0, 10.6 and 5.8 for the four groups, respectively. The mean number of pigs per litter for only the pregnant sows was 9.6, 11.3, 13.3 and 11.0 for the four groups, respectively. Percent conception rate, number of corpora lutea, percent embryo survival, or litter size did not differ significantly among treatments or among boars nor were there any significant interactions.

247. SOME PRELIMINARY STUDIES ON SEX ODOR IN PORK. H. B. Craig and A. M. Pearson, *Michigan State University*.

Preliminary investigations made on tissues from an 18-month-old boar indicate that sex odor is strongest in the parotid gland, fat, testicles, penis and preputial diverticulum. When fat was heated to the boiling point in water, a strong boar odor was evident. Similarly, lean tissue with an admixture of fat produced the characteristic sex odor, although it was less noticeable. Fat from a barrow "control" failed to produce sex odor upon heating. Freeze dried lean tissue freed of fat by ether extraction failed to produce a detectable amount of sex odor on boiling in water. The temperature at which the sex odor is volatilized appeared to be near 100° C. Nitrogen determination of ether extracted fat from a boar and barrow showed no appreciable difference with values for percent nitrogen of 0.149 and 0.141, respectively. When a water extract of boar meat was heated, no sex ordor could be detected, but the residue from the filtration retained the sex odor. Fat extracted at room temperature with acetone, chloroform, ethyl ether or petroleum ether gave off boar odor when heated, but carbon tetrachloride and ethanol extracted fat yielded no sex odor. Thus, results indicate that sex odor in pork is found only in the fatty tissues and that the contributing components may be separated by selective extraction procedures.

248. IDENTIFICATION OF PREPUTIAL GLANDS AS THE SITE OF PRODUCTION OF SEXUAL ODOR IN THE BOAR. R. H. Dutt, E. C. Simpson, J. C. Christian and C. E. Barnhart, *University of Kentucky*.

Removal of the preputial diverticulum reduced the characteristic odor in ranting boars; however, at 10 months of age no difference in "boar" odor was found between carcasses of operated and unoperated boars. Lean areas were free of the odor, but all fat areas sampled gave off "boar" odor when heated. The greatest concentration was found in the fatty tissue of the prepuce, where brownish-orange areas are visible macroscopically in the fatty tissue in the dorsal and lateral regions of the orifice. When fixed and examined microscopically, this tissue has been identified as modified sebaceous glands containing colloid-like material. Glands in the prepuce of barrows appear from histological study to be non-functional. Alcohol-ether extraction of body tissues shows that the agent responsible for the odor is lipophilic and probably is a muscone. Surgical removal of the glandular area was attempted in five immature boars, which were slaughtered at weights varying from 290 to 350 lb. No odor was detected in any portion of the carcasses of two boars from which the preputial glands

has been completely removed. Some odor was detected in carcasses of boars from which upon post-slaughter examination it was found that some of the glandular area had not been removed. It is concluded that preputial glands, dependent upon the male sex hormone for secretory activity, produce a fat-diffusible material which is responsible for sexual odor in boar carcasses.

249. SWINE HEMATOLOGY FROM BIRTH TO MATURITY. E. R. Miller, D. E. Ullrey, Inge Ackermann, J. A. Hoefer and R. W. Luecke, *Michigan State University*.

Over 10,000 hematological determinations were made on blood taken from swine at frequent intervals from birth to maturity. These include hemoglobin level, hematocrit, erythrocyte, leukocyte and reticulocyte enumeration, leukocyte differentiation, total serum protein and serum protein electrophoretic differentiation. Many significant hematological changes occur throughout the productive lifetime of swine. Particularly drastic are the changes which occur in the serum protein electrophoretic patterns in the first few hours and weeks after birth. Certain management practices have a pronounced effect upon cellular components.

250. THE INFLUENCE OF ERYTHROPOIETIN ON BABY PIG ANEMIA. D. E. Ullrey, E. R. Miller, B. G. Harmon, J. A. Hoefer and R. W. Luecke, *Michigan State University*.

Seventy-nine pigs have been used to determine the effect of intramuscular erythropoietin injection at 2 and 5 days of age upon the hemopoietic response to intramuscular iron-dextran injections of either 100 or 150 mg. of iron at 3 days. The pigs were weighed on the 2nd, 21st and 35th day after birth. Hemoglobin, hematocrit, erythrocyte count, reticulocyte count and mean corpuscular volume were determined from blood taken from an ear vein at 2, 3, 5 or 10, 21 and 35 days of age. The iron-dextran injection containing 150 mg. of iron produced a greater hemopoietic response which was sustained for a longer period than that produced by the 100 mg. injection. Weight at 35 days was also favorably influenced by the extra iron. In one litter, which was anemic at 2 days, erythropoietin produced a slight but statistically insignificant hemopoietic response. All other litters were more nearly normal at 2 days, and erythropoietin injections did not produce any observable change in the criteria measured.

251. HEMOGLOBIN AND HEMATOCRIT VALUES IN SUCKLING LAMBS AS INFLUENCED BY IRON-DEXTRAN INJECTIONS. G. V. Hardman, J. G. Mattern, Jr., J. L. Perkins, L. Dozsa, and J. A. Welch, *West Virginia University*.

Because of a lack of published data on the effect of iron injection on young lambs or of the occurrence of iron deficiency anemia, a trial involving the injection of newly born lambs with an iron dextran complex was undertaken. During the lambing season, one-half of all lambs born in the Station purebred flock were injected with 4 cc. iron dextran (Armidexan 50 mg.Fe/cc, Armour Pharmaceutical Co.) within 24 hours after birth. Each treated lamb was paired with a control of the same breed and sex. Blood samples were taken at two-week intervals until lambs reached 10 weeks of age. Blood hemoglobin content was determined by the acid hematin method and hematocrit values were arrived at through a micro-hematocrit technique. The average hemoglobin values for all observations on treated lambs was 10.64 gm./100 ml. blood and 9.44 gm./100 ml. for controls. The average hematocrit values for all observations on treated lambs was 38.76% and 34.76% for controls. Data showed differences between treated and control lambs in hemoglobin levels to be significant ($P=0.05$) for lambs ranging in age from 11 to 50 days, and in hematocrit values for lambs ranging in age from 1 to 50 days. Difference in weight gains up to 70 days of age was not significant. Iron dextran produced no noticeable harmful or undesirable effects.

252. EFFECT OF ALFALFA PASTURE BLOAT ON CERTAIN BLOOD COMPONENTS. L. R. Brown, R. S. Allen, R. H. Johnson and N. L. Jacobson, *Iowa State University.*

During the 1958 and 1959 grazing seasons blood samples were taken from the jugular veins of cattle grazing alfalfa pasture. Approximately 200 samples were collected with an attempt being made to get an equal number from bloated and non-bloated animals at about the same time. The blood was analyzed for red cell volume (1959 only), ammonia nitrogen, total phosphorus, plasma inorganic phosphorus and plasma phospholipid phosphorus. Although the differences in blood composition associated with bloat were greater the first year, all phosphorus components measured were higher in bloated animals both years. Summarizing all data, values for non-bloated and bloated animals, respectively, (standard error of the mean given in parenthesis) were: plasma inorganic phosphorus, 8.58 and 9.44 mg. %, (0.13); total phosphorus, 21.1 and 22.2 mg. %, (0.23); plasma phospholipid phosphorus, 5.98 and 6.33 mg. %, (0.12); hematocrit values, 40.7 and 41.7 %, (0.72), and ammonia nitrogen, 6.0 and 6.0 μg./ml., (1.50). Using only data from animals with values in both classifications, the differences were somewhat smaller: plasma inorganic phosphorus, 8.79 and 9.25, (0.16); total phosphorus, 20.9 and 21.5, (0.31); plasma phospholipid phosphorus, 5.82 and 6.09, (0.16); hematocrit values 40.5 and 41.2, (0.72); and ammonia nitrogen 6.0 and 6.2, (1.10). Of the blood components studied, the difference in plasma inorganic phosphorus levels between bloated and non-bloated animals was most significant ($P<0.005$).

253. BOVINE SERUM CERULOPLASMIN. Charles W. Deyoe and H. O. Kunkel, *Texas A. and M. College System.*

Ceruloplasmin activity has been reported to fluctuate in various stress conditions in the human. This enzyme, an oxidase, was found to be present also in bovine sera. The oxidase activity in cattle, as in humans, is apparently localized in the alpha-globulin fraction of the serum proteins. Within collection periods, differences in enzyme activities were positively correlated to variations in globulin levels. This positive correlation however, was changed with age. Upon analyses of the changes of enzyme activities in a group of young heifers over a period of several months, a significant negative correlation between globulin levels and ceruloplasmin was evident. The enzyme level over the same period was positively correlated with the blood glutathione and the albumin fractions of serum. Therefore the metabolism of this system appears to be intricately related to protein metabolism. Copper fertilization of low-copper-containing pasture forages and cobalt treatment of animals grazing the pastures resulted in a highly significant ($P<0.01$) increase in oxidase activity over that of control animals. This increase in oxidase level was reflected by an increase in total serum proteins and globulins. A significant ($P<0.01$) negative correlation between the enzyme level in the sera and immediate rates of gains was noted in both steers and lambs.

254. ANTIBODY PRODUCTION IN THE BABY PIG. B. G. Harmon, E. R. Miller, D. E. Ullrey, D. A. Schmidt, J. A. Hoefer and R. W. Luecke, *Michigan State University.*

Eighty-nine baby pigs were utilized to study the magnitude of their antibody response to injections of Salmonella pullorum antigen. Different pigs within litters received intraperitoneal injections at weekly age intervals from birth to 6 weeks to determine the effect of age upon antibody titer. All pigs received colostrum and were nursing the dam throughout the study. The amount of antigen administered was proportional to the estimated blood volume of the pigs. Antibody titers were determined

by the tube serial dilution test on serum obtained prior to and 1 week following the administration of the antigen. Average antibody titer of 0, 0, 0, 8, 28, 58 and 196 were obtained for the serum taken one week after antigen administration for pigs aged 0, 1, 2, 3, 4, 5 and 6 weeks, respectively. There was no apparent weight or litter effect upon antibody production within any age group. Total serum protein and serum protein electrophoretic determinations were made on all sera.

255. FURTHER STUDIES ON TASTE PREFERENCES OF DOMESTIC ANIMALS. A. D. Caciagli, Morley R. Kare and W. G. Pond, *Cornell University*.

The ability of the ruminant to discriminate between carbohydrates was studied. The selection of carbohydrates worked with introduced factors such as configuration, optical rotation reduction, osmotic pressure, melting point, density, viscosity as well as sweetness. Saccharin was used as a non-nutritive sweetener. The ruminant's reaction to these materials was not parallel to that of the human. There was no apparent overall correlation between preference or rejection and any of the physical or chemical variables introduced. Similar but less extensive studies were carried out with pigs.

256. ACETATE UTILIZATION BY SHEEP. W. H. Pfander and R. L. Reid, *CSIRO Sheep Biology Laboratory and University of Missouri.*

This paper reports the results of studies on the tolerance test as a measure of acetate metabolism in sheep. The half life t/2 of the injected dose is taken as a measure of utilization. The standard test of Reid (Aust. J. of Ag. Res., 1958) was made on six crossbred, non-pregnant ewes fed a 1:1 mixture of alfalfa hay and wheat hay. Half-lives of 22±2 minutes and 23±2 were obtained in two successive weeks. When the same ewes were fasted 72 hr. t/2 increased to 51±11. Doses of ¼ and ½ standard decreased t/2 and doses of 2 x and 4 x standard increased t/2. Cold stress did not significantly change t/2. Four lambs ate a pelleted 50% concentrate ration *ad libitum;* t/2 was 8±1 minute. A series of tests on four aged wethers (each test conducted a minimum of 28 days after ration change) gave the following t/2 for the rations stated: 2800 gm. lamb fattening ration, 8±1; 700 gm. lamb fattening ration, 13; wheat straw plus mineral and vitamin supplement, 34±5. Where the results from the acetate tolerance tests are compared to the results obtained from concurrent studies with $C^{14}$ acetate and A-V differences, it appears that the tolerance test can be very useful under carefully defined experimental conditions but would be of less value as a diagnostic tool.

257. RELATIONSHIP OF DEVELOPMENT OF RUMINAL MUCOSAE OF LAMBS TO FEED CONSUMPTION AND FEEDLOT PERFORMANCE. H. O. Kunkel, Fehrlin E. Tutt, Joe D. Robbins, and John H. Sinclair, *Texas Agricultural Experiment Station.*

The anterior ventral sacs of rumina of 200 lambs fed under several dietary regimens were examined for developmental variations. Pelleting a diet of 40% ground sorghum grain, 10% molasses, 35% cottonseed hulls, 5% alfalfa leaf meal, and 10% cottonseed meal had only a small effect on average papillary length. Implantation of 3 mg. diethylstilbestrol (DES) 75 days prior to slaughter resulted in a significant increase of 0.5 mm. in length of papillae. Protein source (cottonseed meal or soybean oil meal), dietary chlortetracycline, oxytetracycline, terephthalic acid, or hydroxyzine had no significant effect on morphology of the mucosae. Gross and within treatment coefficients of correlation between papillary length and previous rates of gain of 86 unimplanted lambs were 0.48 and 0.50, respectively. Corresponding coefficients for 90 lambs with DES implants were 0.17 and 0.16, respectively. Lambs showing signs

of sloughing of papillae and a subsequent regeneration in progress had significantly lower rates of gain than lambs exhibiting evidence of uninterrupted development. Examination of eight lambs fed individually indicated a significant positive correlation between immediate voluntary feed consumption and length ($r=0.74$, $p<0.05$), width ($r=0.76$, $p<0.05$), and density ($r=0.68$) of papillae. A significant occurrence of ruminal infantilism and/or retrogression in feedlot lambs is suggested and appears responsible, in part, for the variation in feedlot performance.

258. EFFICIENCY OF WEIGHT GAINS IN DAIRY CALVES DURING GROWTH AT 50° AND 80° F. H. D. Johnson, H. H. Kibler, A. C. Ragsdale, *University of Missouri.*

Body weight gains, energy metabolism, TDN consumption, and thyroid $I^{131}$ release rates were measured in two groups of growing Jersey, Holstein and Brown Swiss female calves raised at 50° and 80° F. Each temperature group comprised three animals of each breed. Maximum gains of 2.4 lb./day at 5 to 6 months of age in Holstein and Brown Swiss decreased to 1.8 at 12 months. Gains in the 80° F. Jerseys were about constant at 1.2 lb./day to 12 months, and 1.4 at 50° F. up to 8 months. The ratios of weight gain to TDN, to energy metabolism, and to thyroid $I^{131}$ release rate decreased during growth. However, the weight gain/thyroid $I^{131}$ release rate decreased much less with advancing age than the other ratios. At 50° F. these ratios were greater in the Brown Swiss than Holsteins and Jerseys. At 80° F. breed differences in these ratios were less pronounced. Weight gain/thyroid $I^{131}$ release rate was greatest in the Holsteins, least in the Jerseys, and intermediate in the Brown Swiss. The 50° and 80° F. ratios were similar with the exception of the weight gain/thyroid $I^{131}$ release rate of the Brown Swiss, which was greater at 50° than 80° F. The time factor must be considered in evaluating energetic efficiency at the 50° and 80° temperatures. Evidence of "acclimation" is strong in the 80° F. reared Jerseys and suggested in the 80° F. reared Holsteins. Over the 10-month period of efficiency of weight gain was greater in the Brown Swiss at 50° F., and in the Jerseys and Holsteins at 80° F.

259. EFFECT OF ENVIRONMENTAL TEMPERATURES ON SURFACE TEMPERATURES OF GROWING CALVES. M. D. Shanklin, R. E. Stewart, H. D. Johnson, and H. H. Kibler, *University of Missouri and USDA.*

The effects of environmental temperatures (50° F. and 80° F.) on the surface (skin and hair) temperatures and hair density were measured on Brown Swiss, Holstein, and Jersey calves. The calves were placed in the test rooms of the Missouri Climatic Laboratory at approximately 8 to 10 weeks of age and were held at constant environmental conditions for about 13 months. Skin and hair temperatures were determined weekly using touch thermocouples, and hair density was measured approximately monthly with a "Beta gauge" (source radiation, $Pm^{147}$). Graphic analysis of the surface temperature vs. body weight showed that at both 50° F. and 80° F., skin temperatures of all breeds decreased with increasing body weight. The skin temperatures of the Jerseys were markedly lower than those of the Brown Swiss and Holsteins. The hair temperatures of the Brown Swiss and Jerseys decreased with increasing body weight at 80° F., while that of the Holsteins' increased. At 50° F., the hair temperatures of all three breeds increased during growth. Hair density plotted vs. weight showed an inverse relationship to the surface temperature (both skin and hair) vs. body weight for all breeds at both environmental temperatures. The hair density of the 50° F. calves was greater than that of the 80° F. calves in all three breeds. For example, hair density values for Jerseys, Holstein and Brown Swiss at 50° F. were 9, 15, and 14 mg/cm$^2$ respectively and 6, 8, and 7 mg/cm$^2$ respectively at 80° F.

260. THE AGE AND WEIGHT AT PUBERTY IN HEREFORD HEIFERS. J. N. Wiltbank, W. W. Rowden, and J. E. Ingalls, *Beef Cattle Research Station.*

Age and weight at puberty were studied in 125 Hereford heifers. Checks for estrus were started at weaning time (oldest heifers were approximately 250 days old). Vasectomized bulls were run with the heifers. A multipurpose grease was placed on the brisket of these bulls once or twice daily. Heifers were checked for grease marks daily. A heifer was declared in heat when she was found marked with grease on either the rump or tail head. Weights were taken and ovaries palpated at 28-day intervals. Heifers were run on the range during the winter and were fed 1 lb. of a 41% protein supplement per head daily. The average gain from weaning to grass in the spring (approximately May 1st) was 0.38 lb. daily. Only 11 (9%) heifers reached puberty before grass started. The average age at puberty was 434 days (does not include two heifers which have not reached puberty) and the standard deviation was 26.6. The average weight at puberty was 562 lb., and the standard deviation was 53.0. The average gain from weaning to puberty was 158 lb. with a standard deviation of 50.0. The correlation between weaning weight and age at puberty was —.23 and between gain from weaning to puberty was 0.77.

261. EFFECT OF BREED CLASSIFICATION, SEX, AND SEX OF CO-TWIN ON FETAL DEVELOPMENT IN LAMBS. W. C. Foote and Darrell H. Matthews, *Utah State University.*

Twin lambs born during the years 1945–59 (2625 pairs; Columbia, Rambouillet, Targhee and Hampshire- and Suffolk-Whiteface cross) were classified into four groups, male with male and female co-twin and female with male and female co-twin and analyzed for differences in birth weights. One member of each twin pair was used. Separate analyses were made for 1958 (180 lambs) and 1959 (200 lambs) because additional birth measurements were taken; orthogonality was attained by discarding data at random as required within sub-groups. Distribution of sex did not differ from the expected 1♂♂: 2♂♀: 1♀♀ ratio. In the 1945–59 analysis males were significantly heavier than females, 9.78, ♂(♂); 9.80 lb. ♂(♀) vs. 9.30, ♀(♀); 9.17 lb. ♀(♂) with no effect due to sex of co-twin. In 1959 Blackface-cross lambs were significantly greater than Targhee and Rambouillet with Columbia tending to be intermediate for body weight, hip width, chest circumference, and head circumference; except for the latter where Suffolk-cross failed to differ from Rambouillet. No significant differences were found for metatarsus plus tuber calcis length. Significant differences in lambs in co-twin classification were again found for most measurements due to sex of the lamb but not for sex of co-twin. However, female with male tended to be heavier than female with female co-twin. In 1956 Hampshire-cross had significantly greater body weight and head circumference, Hampshire-cross and Rambouillet greater shoulder width, Rambouillet tended to have greater head length with no differences in head width. No significant differences were found in 1956 among lambs in co-twin classification for any of the measurements taken. No significant breed x co-twin classification interactions were found for any measurements taken in either year.

262. TWENTY-EIGHT DAY GAIN VS. INITIAL WEIGHT AS A PREDICTOR OF SUBSEQUENT GAIN IN IMMATURE HEREFORD STEERS. J. W. Van Stavern and E. W. Klosterman, *Ohio Agricultural Experiment Station.*

The data for this study were obtained from Hereford steers on feeding experiments at the Ohio Station during the years 1954–55, 1957–58, and 1958–59. All the animals were purchased from the same herd and arrived by rail during the fall of each year. For the year 1954–55 preliminary gain was determined for 112 days whereas for the

other two years it was determined for only 28 days. In 1957–58 all weights and gains were on a shrunk weight basis. In other years they were based on full weights. Gross correlation was computed between initial weight and subsequent gain and between preliminary gain and subsequent gain for each group of steers. The data were subjected to covariance analysis utilizing both initial weight and preliminary gain as the predictor. The relative efficiency of covariance was determined for each group of animals. Twenty-eight-day gain and 112-day gain based on full weight were inferior to initial weight as a predictor of subsequent gain, whereas 28-day gain based on shrunk weight was about equal to initial weight as indicated by correlation coefficients and relative efficiency of covariance. Only two groups of animals yielded significant correlation coefficients and these were near the same whether initial weight or shrunk 28-day gain was used as the predictor.

263. EVIDENCE FOR EXISTENCE OF A MAMMOGENIC HORMONE. H. C. Damm and C. W. Turner, *University of Missouri.*

A review of the literature indicated that since the discovery of the necessity of the anterior pituitary gland for mammary gland growth, attempts have been made to isolate an active fraction (Mammogen) primarily responsible for this phenomenon. While earlier work postulated the existence of two different hormones, one responsible for duct growth and one for lobule-alveolar growth, evidence presented more recently indicated that one hormone is responsible for both actions. Statistical procedures are described for the determination of mammary gland growth promoting potency of certain substances, using desoxyribonucleic acid as an index of mammary gland growth. The resultant assay method was applied in experimental extractions of anterior pituitary gland. A method of extraction of anterior pituitary tissue is described which yields a light grey, amorphous powder, 223 times more potent in promoting mammary gland growth than progesterone and containing negligible, if any, lactogenic activity. In addition to the six recognized anterior pituitary hormones which have been characterized biologically, evidence is presented indicating the presence of a mammogenic hormone which is separate from the lactogenic hormone.

264. OPTIMAL HORMONAL LEVELS IN MAMMARY GLAND GROWTH. Richard C. Moon and Charles W. Turner, *University of Missouri.*

The beneficial effect of thyroid hormone upon lactation is well established; however, little is known concerning the role of this hormone upon mammary gland growth. Experiments were designed to determine the optimal level of thyroxine secretion in intact, ovariectomized, and ovariectomized rats injected daily with 1 μg. estradiol benzoate (EB) and 3 mg. progesterone (P). Average thyroxine secretion rates (TSR) were 1.10, 0.66 and 1.20 μg./100 gm. l-thyroxine, respectively. Thyroxine level of 3.0 μg/100 gm./day was selected as optimal since this was the highest observed individual TSR. Ovariectomized rats received daily subc. injections of 1 μg. EB + 3 or 6 mg. P or 2 μg. EB + 6 mg. P alone or in combination with 3.0 or 6.0 μg./100 gm. l-thyroxine for 19 days. Desoxyribonucleic acid (DNA) was used as an index of mammary gland growth. Mammary gland DNA of rats receiving 1 μg. EB + 3 or 6 mg. P was comparable to that of rats pregnant 18–20 days. Increasing the EB and P levels did significantly alter mammary gland DNA. Thyroxine (3.0 or 6.0 μg.) in combination with 1 μg. EB + 3 mg. P had little effect upon mammary growth but when administered with 2 μg. EB + 6 mg. P, a highly significant increase in DNA was observed. These data suggest that the thyroid hormone may be a limiting factor in mammary gland growth and that an elevated thyroxine level increases the requirements for estrogen and progesterone above that which produces optimal mammary growth in animals with sub-optimal levels of thyroid hormone.

265. EFFECT OF PREGNANCY UPON PITUITARY LACTOGENIC HORMONE CONCENTRATION. Clark E. Grosvenor and Charles W. Turner, *University of Missouri.*

A study was made to ascertain whether growth and secretory phases of rat mammary gland during pregnancy were associated with variation in concentration of pituitary lactogenic hormone. Pituitary lactogen levels were determined by the common pigeon micro method of assay. Pituitary weight was low during most of pregnancy, but increased markedly a short time before parturition (day 21). Pituitary lactogen, however, increased during the first two-thirds of pregnancy during which time there was growth, but little secretory activity of the mammary gland. Peak concentration (0.051 I.U./mg. pituitary) was reached on day 16. As the secretory activity of the mammary gland progressively increased during the last third of pregnancy, pituitary lactogen levels decreased markedly reaching the lowest point (0.004 I.U./mg.) on day 21. These data suggest a progressive secretion of lactogen occurs during the period of mammary gland growth, then is discharged during the period of mammary gland growth, then is discharged during the latter part of pregnancy to initiate prepartum secretory activity of mammary gland alveoli. The influence of 1, 3.6, 15 and 50 μg./day estradiol benzoate (E.B.) for 5 days upon pituitary weight and lactogen concentration was studied in mature female rats. Maximum pituitary enlargement occurred with 15 μg./day E.B., whereas pituitary lactogen increased as the log-dose of E.B. The level resulting from 1 μg./day E.B. (0.054 I.U./mg.) closely approximated the highest level found during pregnancy.

266. PARATHORMONE AND LACTATION. R. von Berswordt-Wallrabe and C. W. Turner, *University of Missouri.*

Thyro-parathyroidectomy was performed in 58 albino rats at day 4 of lactation. The mother rats lost considerable body weight after the operation owing, at least partially, to a reduced food intake. Replacement therapy was started immediately after operation. All animals received daily 3.5 mcg. 1-thyroxine/100 gm. body weight and graded amounts of parathormone (PH) until day 13 and day 14 of lactation, respectively. Based on the litter weight increase, daily injections of 10, 2 x 20 and 3 x 20 USP units of PH did not restore lactation to average control levels, whereas seven animals with presumed accessory parathyroid tissue reached normal or better than control levels. However, based on the weight of milk obtained on day 14 of lactation under standardized conditions, expressed as percent of the litter body weight as a criterion, 3 x 20 USP units PH/day resulted in successful replacement therapy in 10 animals. Many incidents of tetany were recorded after discontinuing the PH supply and also in excellent lactating animals which were given 2 x 20 USP units PH/day. The withdrawal of PH on day 13 resulted on day 14 of lactation in a reduced blood calcium level, tetany, nervousness, depressed food intake and body weight, irregular nursing, disturbed lactogenic hormone discharge from the pituitary gland, presumably in an interruption of the "let-down" mechanism and in markedly reduced milk yields.

267. ELEVATED THYROXINE POOL AND LACTATION. B. N. Premachandra and C. W. Turner, *University of Missouri.*

Information has not been available so far relating hyperthyroidism in terms of thyroxine secretion rate although the beneficial effects of a mild hyperthyroid state are generally recognized. Thyroxine secretion rates of two cows (one Guernsey and one Jersey-Holstein cross) were determined in late winter and the animals were maintained 50% above their daily secretion rate with exogenous thyroxine. The equilibrium body pool of thyroxine, computed on 28% turnover per day, was shifted from one secretion rate level to another immediately to eliminate the time which

would otherwise be needed for a gradual build-up of the hormone in the body. Both the cows responded immediately with the Guernsey giving 37% more milk and the Jersey-Holstein cross 22% more milk. The maximum response was attained in 3–5 days as contrasted to several weeks that is normally required. After the milk production plateau was achieved at 50% higher thyroxine secretion rate level, the animals were then maintained 100% above their original daily thyroxine secretion rate. The Guernsey showed a further response by 5% more milk, whereas in the other the increase was not marked. The significant observations are (1) the rapidity with which maximum milk production is attained when the equilibrium pool of thyroxine is instantaneously shifted from one level to another, (2) maintenance of high plane of milk yield for several months and especially, in summer, also. The latter observation would further suggest that animals can withstand the winter level of thyroxine in summer and maintain high milk yield.

268. ABILITY OF DRUGS AND NEUROHORMONES TO INDUCE LACTATION. Joseph Meites, *Michigan State University*.

Several drugs and neurohormones have been tested in our laboratory in an attempt to elucidate the mechanisms responsible for prolactin release and initiation of lactation. Intact mature female rats were injected with estradiol for 10 days to induce mammary development, and were then given one of the drugs for 5 days to see whether it would initiate milk secretion. On the 16th day the mammary glands were removed and examined histologically. The following substances were found to be effective in initiating lactation: epinephrine, norepinephrine, acetylcholine, pilocarpine, serotonin, reserpine, carbethoxysyringoyl methylreserpate (Ciba) and atropine. In the doses used, the following substances showed no ability to initiate lactation: oxytocin, vasopressin, histamine, amphetamine, physostigmine, nembutal, morphine, lysergic acid diethylamide, chlorpromazine and SKF 6270-A. Several drugs were able to maintain mammary secretion in postpartum rats for 10 days after litter removal: epinephrine, acetylcholine, serotonin, reserpine, oxytocin and to a slight degree, vasopressin. It is not known whether the effective drugs act directly on the anterior pituitary or through the hypothalamus to evoke prolactin release. The ability of adrenergic and cholinergic substances to induce and maintain lactation suggests that the autonomic nervous system is involved in the normal control of lactation. The autonomic nervous system drugs have also been found to induce lactation in guinea pigs and rabbits, and will be tested in dairy animals.

269. STUDY OF THE EFFECT OF TIME ON EXPERIMENTAL MAMMARY GLAND GROWTH AND LACTATION IN DAIRY HEIFERS. Ralph Williams and C. W. Turner, *University of Missouri*.

Two groups of heifers, seven per group, were studied: Group I injected for 4 months; Group II injected for 6 months. All heifers received 200 mg. progesterone; three heifers in group I and four heifers in group II received 200 $\mu$g. of estradiol benzoate, injected daily with the progesterone. The remaining animals in each group were fed 20 mg. of diethylstilbestrol daily. During the last 30 days of the growth period all heifers in group II received increasing doses of estradiol benzoate from 1 mg. up to 3 mg. per day. To initiate lactation all animals were injected with 0.3 mg. estradiol benzoate per 100 lb. body weight for 14 days. Milking was started 12 hours after the first injection. No difference in production was noted between estradiol benzoate injected and diethylstilbestrol fed heifers in either group. In group I maximum daily milk production based on a weekly average ranged from 20.7 to 23.6 lb.; in group II from 20.2 to 30.9 lb. After each group reached a peak and all heifers were declining in production, the heifers in group I were injected with 0.3 mg./100 lb. body weight estradiol benzoate daily; heifers in group II were fed 30 mg./100 lb. body weight

diethylstilbestrol daily for 1 week. Average milk production of group I increased, exceeding the original peak by 18.8% and remaining above that level for 10 weeks. Production of the diethylstilbestrol fed group varied, the average for the group increased to slightly below the original peak for the group.

270. EFFECT OF TEREPHTHALIC ACID ON CHLORTETRACYCLINE CONCENTRATION IN SOWS MILK AND BLOOD SERUM AND IN THE BLOOD SERUM OF SUCKLING PIGS. B. F. Thorpe, V. C. Speer, J. D. Jones, V. W. Hays and D. V. Catron, *Iowa State University of Science and Technology.*

Forty crossbred sows and litters were used to study the potentiating effect of terephthalic acid (TPA) on chlortetracycline absorption in lactating sows. No antibiotic activity was found in the blood or the milk of the sows fed the control diet or TPA alone. When TPA (0.5%) was fed in combination with chlortetracycline (200 gm./ton) an average of 56% higher levels (0.72 vs. 1.12 mcg./ml.) of chlortetracycline was found in the milk and 75% higher levels (0.42 vs. 0.74 mcg./ml.) in the blood of the sows as compared to sows fed chlortetracycline alone. It was further found that the pigs nursing sows fed a combination of TPA and chlortetracycline had an average of 59% higher chlortetracycline level (0.24 vs. 0.38 mcg./ml.) in their serum than pigs nursing sows fed chlortetracycline alone.

271. AN INSTRUMENT FOR MEASURING THYROID $I^{131}$ ACTIVITY *IN VIVO* FOLLOWING VERY LOW DOSAGES TO CATTLE. J. R. Howes, W. A. Higinbotham, J. F. Gennaro and J. P. Feaster, *University of Florida and Brookhaven National Laboratory.*

An instrument will be described which enables the thyroid uptake and release of radioactive iodine to be effectively measured *in vivo* in adult cattle, use being made of relatively low dosages of $I^{131}$. The instrument embodies many well known features, but is unique in that the input from two scintillation tubes may be read on one ratemeter. Such a device provides a more efficient geometrical coverage of biological radioactive material. Apart from the application here described this instrument has also been used for *in vivo* measurements of the radioactivity from small laboratory animals moving freely in cages placed between the two tubes. Hitherto, relatively large doses of $I^{131}$ have been employed for thyroid uptake studies in cattle (50 microcuries to over 20 millicuries per animal). Doses of from 1 to 30 microcuries were successfully employed with the instrument described to measure thyroid uptake and release of $I^{131}$. The most successful dose appears to be 5 microcuries per adult bovine. This dose provided measurable activity above background for a reasonable length of time. The possible confounding of thyroid function with radiobiological effect is considerably reduced, since the critical tissues receive a much lower dosage.

272. PRELIMINARY STUDIES OF THYROXINE TURNOVER METHODS FOR ESTIMATING THYROID SECRETION RATES USING EITHER STABLE OR RADIOACTIVE THYROXINE. T. B. Post and J. P. Mixner, *New Jersey Agricultural Experiment Station.*

Within animal comparisons were made of two thyroxine turnover methods for estimating thyroid secretion rates in eight young dairy bull calves. In the radioisotope method 50 $\mu$c. of $I^{131}$ tagged thyroxine was injected intravenously in a single dose. Blood samples, drawn daily during the following four days, were chemically assayed for $PBI^{127}$ and radioassayed for $PBI^{131}$. The thyroxine turnover rate was calculated from $\log_e$ of specific activities of circulating thyroxine versus time. The extrathyroidal thyroxine pool was calculated by isotope dilution methods. Thyroid secretion rate was estimated as the product of the thyroxine turnover rate and of the extrathyroidal

thyroxine pool. In the chemical method 5 mg. of stable L-thyroxine was injected intravenously in a single dose. Blood samples were drawn periodically over a period of 3 days and chemically assayed for $PBI^{127}$, from which were calculated thyroxine turnover rates and volumes of distribution. Thyroid secretion rates were calculated as the products of the normal levels of PBI, thyroxine turnover rates and thyroxine volumes of distribution. With both methods the kinetics of thyroxine turnover rates might warrant some type of adjustment in these values. When no adjustments were applied the mean thyroxine turnover rates per day were $0.377 \pm 0.036$ and $0.381 \pm 0.019$ for the radioisotope and chemical methods, respectively. Correspondingly, the daily L-thyroxine secretion rates (mg. per 100 lb. of body weight) were $0.464 \pm 0.064$ and $0.401 \pm 0.048$. There was a coefficient of correlation of 0.87 between daily L-thyroxine secretion rates as determined by the two methods.

273. A COMPARISON OF THE THYROID RELEASE OF $I^{131}$ BY HEREFORD AND BRAHMAN CATTLE UNDER IDENTICAL ENVIRONMENTAL CONDITIONS. J. R. Howes, J. P. Feaster and J. F. Hentges, Jr., *University of Florida.*

To study the differences of response of British and Indian breeds of cattle to high ambient temperatures, comparative levels of thyroid activity were measured. Twelve Hereford and 12 Brahman registered non-pregnant 2-year-old heifers were allocated at random into two treatments, 100% and 50% of the N. R. C. recommended protein allowances respectively. In midsummer, after 1 year on these rations, each of the 24 animals was intravenously injected with 5 microcuries of $I^{131}$. At various intervals of time thereafter the necks of the animals were monitored with two scintillation tubes, the input from both going into one ratemeter. At the time of injection a control tube into which 5 microcuries of $I^{131}$ had been injected was monitored with the same equipment. The time for maximum uptake of $I^{131}$ by the thyroid averaged 72 hours for Herefords and 94 hours for Brahmans. There was a pronounced species and ration difference in the amount of $I^{131}$ absorbed by thyroids. A greater percentage of the dosage was absorbed by the thyroids of the Herefords, but the Herefords on the low protein intake absorbed as much isotope as the Brahmans on the high protein intake. The rate of release of thyroid $I^{131}$ was faster for the Herefords, and for all cattle on the high protein intake.

274. THYROID STIMULATION IN RATS AS A RESULT OF FEEDING GRASS SILAGE. R. O. Asplund, G. A. McLaren and I. D. Porterfield, *West Virginia University.*

Grass silage suspected of causing unusually high plasma protein-bound iodine (PBI) values in dairy cattle was tested for its effect on thyroid activity. Experimental rations consisted of 1 part air dried, ground grass silage and 4 parts of a basal ration containing 18.6% protein. The control ration, prepared by replacing grass silage with a mixture of 50% cellulose, 40% corn starch and 10% purified soybean protein, contained approximately the same amount of fiber, energy and nitrogen as the experimental rations. Criteria for measuring thyroid activity were basal metabolic rate (BMR), plasma PBI and histological examination. After 7 days the mean BMR of rats fed the silage ration was 15% greater than that of rats fed the control ration and the mean PBI was 230% greater. After 60 days the mean BMR was 31% greater and the mean PBI 11% greater than values obtained with rats fed the control ration. Correlation between BMR and PBI values was 0.39. All values were significant at either the 1% or 5% level. Comparison of the appearance of histological sections of the thyroid glands of the two groups revealed definite differences. The thyroids of rats fed silage were similar to those of rats treated with thyroid stimulating hormone. Rats fed a grass hay or similar forage content to that of the silage and grown in a

field adjacent to that from which the silage was taken exhibited no changes in any of the three criteria considered in this work.

275. THE INFLUENCE OF ESTRADIOL-PROGESTERONE AND DES IMPLANTS ON THE WEIGHT AND GROWTH HORMONE ACTIVITY OF ANTERIOR PITUITARIES FROM FATTENING STEERS. F. C. Hinds, B. G. Smith, A. L. Neumann, and G. E. Mitchell, Jr., *University of Illinois.*

Forty yearling Hereford steers were allotted at random to two groups of 16 and one group of eight. One group of 16 steers was implanted with diethylstilbestrol (DES), the other group of 16 was implanted with Synovex (200 mg. progesterone and 20 mg. of estradiol) and the group of eight remained untreated. When the animals were slaughtered the anterior pituitaries were collected and frozen in dry ice. They remained frozen until prepared for desiccation, at which time the wet weight was obtained. After desiccation for at least 48 hours, the dried tissues were reduced to a powder, weighed, and then stored at 0° F. All 40 pituitaries were individually assayed for [illegible] hormone by using the "tibia test". The DES-treated and Synovex-treated s[illegible] faster, had heavier anterior pituitaries and had more anterior pituitary [illegible] of live weight than the untreated steers. The results of the growth hor[illegible]dicate that there are no differences in the concentration, per unit weight [illegible]tuitary, of growth hormone activity between the pituitaries of control and treated steers. However, when growth hormone activity per whole pituitary or when total growth hormone activity per lb. of steer was calculated, significant differences were found. Although the pituitaries of estrogen-treated cattle increase in size, apparently there is no change in the concentration of growth hormone activity per unit weight of the pituitary. Thus, more growth hormone activity is available to the animal by virtue of a larger pituitary.

276. THE INFLUENCE OF ESTRADIOL-PROGESTERONE AND DES IMPLANTS ON THE RNA AND DNA CONTENT OF ANTERIOR PITUITARIES FROM FATTENING STEERS. F. C. Hinds, T. C. Detwiler, H. H. Draper, G. E. Mitchell, Jr. and A. L. Neumann, *University of Illinois.*

The nature of the increase in size of the anterior pituitary of steers treated with diethylstilbestrol (DES) and Synovex (200 mg. progesterone and 20 mg. estradiol), with respect to changes in cell size, cell number, percent nitrogen and potential for protein synthesis, was studied by determining the RNA, DNA, and nitrogen content of representative pituitaries. The anterior pituitaries from control steers and steers implanted with DES and Synovex were collected at slaughter. All of the pituitaries were lyophilized. Five pituitaries from each treatment group were selected according to their dry weights so that heavy, medium and light pituitaries were extracted and the RNA and DNA determined as RNA- and DNA-phosphorus. Nitrogen was determined by the micro-Kjeldahl method. There were no statistically significant differences between lyophilized pituitaries of control, DES-treated, and Synovex-treated with respect to the concentration of RNA, DNA, or nitrogen per 100 mg. of tissue or the ratio of RNA to DNA. However, when the total RNA and DNA per pituitary was calculated, DES-treated and Synovex-treated steers had significantly greater amounts. The increased weight of the pituitary of the DES-treated and Synovex-treated steers was the factor that resulted in significant differences. The increase in size of pituitaries from estrogen-treated cattle is due to an increase in cell number (total DNA per pituitary), with no apparent change in cell size (DNA per unit weight). The potential for protein synthesis per unit of weight (RNA per unit weight) was not influenced nor was the amount of nitrogen.

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# NEWS AND NOTES

*Meeting of the American Society of Animal Production.* The 51st annual national meeting of the Society will be held in the Hotel Sherman, Chicago, Friday and Saturday, November 27 and 28, 1959. Sessions for presentation of papers will be held Friday, 9:30–11:00 a.m. and 1:00–4:00 p.m., and on Saturday 9:00 a.m.–4:00 p.m. and 7:30–9:30 in the evening. The General Session will be held Friday, 11:00 am.–12:00. Annual dinner and business meeting will be held Friday evening at 6:00 p.m.

*The Nominating Committee* of the American Society of Animal Production has proposed the following slate of candidates for presentation at the annual business meeting: For President, J. K. Loosli; for Vice-President, H. H. Stonaker; for Secretary-Treasurer, J. C. Hillier and C. E. Terrill.

*The North Atlantic Section* of the Society met at the University of Connecticut, August 25–26, 1959 Proceedings in mimeograph form which include the 27 papers presented at the meeting may be obtained from George W. Vander Noot, Department of Animal Husbandry, Rutgers-The State University, New Brunswick, New Jersey. The price is $2:00. The next meeting of the Section will be held at the University of Massachusetts, Amherst, August 23–24, 1960. Officers for the year 1959–1960 are W. W. Green, University of Marryland, President; W. A. Cowan, University of Connecticut, Vice-President; and G. W. Vander Noot, Secretary-Treasurer.

*The Southern Section* of the Society will hold its annual meeting as part of the 57th annual meeting of the Association of Southern Agricultural Workers in Birmingham, Alabama, February 1–3, 1960. Headquarters hotel will be the Pick-Bankhead Hotel where the meetings will be held. Titles of papers should be sent to the Southern Section secretary, George K. Davis, Nutrition Laboratory, Florida Agricultural Experiment Station, Gainesville, Florida, not later than November 1 and abstracts not later than November 20, 1959. Publication of abstracts is planned for the May issue of the Journal. There will be no opportunity for authors to read proof on the abstracts or revise them so every effort should be made to submit them in final form.

*"Germ Plasm Resources in Agriculture: Development and Protection"* is the title of the symposium to be held in Chicago, Illinois, December 28–30, 1959. This is the program of Section 0 (Agriculture) of the AAAS. This symposium is being cosponsored by four other sections of AAAS and by 15 professional organizations including the American Society of Animal Production. There will be five half-day sessions held in Exhibit Hall (South), Morrison Hotel, starting 9 a.m., December 28. R. E. Hodgson, Animal Husbandry Research Division, Beltsville, Maryland, is chairman. The full program is given in Science 129:1435 (May 22, 1959).

An official delegation of 20 members and some 80 other individuals represented the United States as guests of the British government at the meetings of the 15th International Dairy Congress held in the midst of well known British pageantry in London, England, June 29–July 3. Delegates and members from more than 40 countries were in attendance to hear and discuss over 400 papers on dairy science and marketing that were included in the program. Technical sessions and lectures were held in the mornings and tours to farms, dairy plants and colleges and institutes were held in the afternoon while the evenings were given over to entertainment.

The Queen Mother formally opened the Congress, at which time she spoke of the important role that the dairy cow and her product play in human welfare. The Congress resolved that intensified efforts should be made to extend the use of milk and its products in warm countries; that governments of all countries should sympathetically consider adoption of the Code of Principles, Standards and Definitions

for Milk and Milk Products elaborated by a committee of FAO; that encouragement be given efforts to secure international agreement on reference methods for examination of milk and milk products; and that the International Dairy Federation establish a commission to coordinate research on butterfat.

The United States recently sent an Animal Husbandry Team to the U.S.S.R. as a part of the Cultural Exchange Program to have a look at the Soviet livestock industry and the research and educational programs relating to animal husbandry. This team was a counterpart to a U.S.S.R. Animal Husbandry Team that visited the United States in the summer of 1958.

The team consisted of L. E. Hanson, University of Minnesota; E. E. Heizer, University of Wisconsin; A. V. Nalbandov, University of Illinois; A. H. Tillman, Oklahoma State University; W. Keller; C. E. Terrill; and R. E. Hodgson (Chairman), U.S.D.A. The team was in the U.S.S.R. from August 5 to September 7, 1959. During this time visits were made with animal husbandry research and educational specialists at the Ministry of Agriculture, agricultural institutes, and animal husbandry experiment stations. Visits were also made to some 15 State and collective farms. The tour included the areas in and around the cities of Moscow, Leningrad, Riga, Kiev, Kharkov, Askanaya Nova, Semferopol, Stavropol, Alma Ata and Rubtrovsk which included the important agricultural and livestock growing regions of the U.S.S.R.

The team members were impressed with the progress that the Soviet Union is making in the improvement in the production of cattle, sheep, swine and poultry and their products. A report of the results of this study will be forthcoming and made available to the public at a later date.

Stanley D. Musgrave has been appointed Professor and Head of the Department of Dairying at Oklahoma State University where he has been a member of the department since 1951. Dr. Musgrave received his B.S. and M.S. degrees from the University of Illinois and his Ph.D. degree from Cornell.

W. Darrell Foote has joined the staff of the Animal Husbandry Department at the University of Nevada as Assistant Professor and Assistant Animal Husbandman. Professor Foote received his B.S. degree from Utah State and is completing work for his Ph.D. degree at the University of Wisconsin. He replaces J. F. Kidwell who will be at Iowa State College for advanced study on a Guggenheim Foundation Fellowship for the next year.

Anthony Lesperance, who received his B.S. degree from California Polytechnic College and his M.S. degree at the University of Nevada, has joined the staff of the Animal Husbandry Department at Nevada as Junior Nutritionist. He will be working on molybdenum toxicity.

W. E. Ellis, formerly of the Department of Animal Husbandy, University of Missouri, is currently fulfilling a 9-month NATO post doctoral fellowship in the Physiology Department, Rowett Research Institute, Burksburn, Aberdeenshire, Scotland.

Billy G. Diggs joined the staff of the Animal Husbandry Department at Mississippi State University on June 1. Dr. Diggs recently received his Ph.D. degree in Animal Nutrition at the University of Illinois. He will be in charge of swine nutrition work at Mississippi.

H. W. Essig joined the staff of the Animal Husbandry Department at Mississippi State University on September 1. Dr. Essig completed requirements for the Ph.D. degree in August and will be in charge of ruminant nutrition work at Mississippi.

George H. Hart, Dean Emeritus of the University of California School of Veterinary Medicine, died August 2 in Woodland, California.

Robert M. Koch has been named Chairman of the Department of Animal Husbandry at the University of Nebraska, College of Agriculture, succeeding Professor W. J. Loeffel. Professor Loeffel was Chairman of the Department for 19 years and has been with the Department for 40 years. He will remain on the staff as Professor of Animal Husbandry. Dr. Koch has been a member of the Animal Husbandry staff at Nebraska since 1950.

C. E. Shelby has been designated to direct the Regional Swine Breeding Laboratory, with headquarters at Iowa State in Ames. Dr. Shelby holds B.S. and M.S. degrees from Kentucky and a Ph.D. from Iowa State. He comes to Ames from Denver, where he was associated with the beef cattle breeding research program, AHRD, ARS. Dr. Shelby succeeds Dr. W. A. Craft who has directed the Laboratory since it was organized in 1936.

Alvin A. Price, Dean of the School of Veterinary Medicine at Texas A and M College since September, 1957, was promoted to Assistant Director of the Texas Agricultural Experiment Station effective September 1. His new duties include the planning and coordination of the expanding research in veterinary medicine; he will also continue as Dean of the School of Veterinary Medicine.

James W. Burch, retired June 30 after serving as Director of the Missouri Agricultural Extension Service for 25 years, was appointed as Extension Animal Husbandman on a part-time basis, July 1, 1959.

Raymond L. Arthaud, formerly Animal Geneticist with the Animal Husbandry Research Division, ARS, USDA, located at the University of Nebraska, Lincoln, resigned from the USDA effective June 30, 1959, to become Extension Specialist in Animal Husbandry with the Minnesota Institute of Agriculture, St. Paul.

George E. Nelms has been appointed Assistant Professor of Animal Husbandry, University of Wyoming, effective June, 1959. He succeeds Dr. Paul O. Stratton, who became head of Wyoming's Animal Husbandry Department. Dr. Nelms was previously Assistant Animal Husbandman at the University of Arizona.

Nat M. Kieffer has accepted a position as Animal Geneticist with the USDA at the U.S. Range Livestock Experiment Station at Miles City, Montana. Dr. Kieffer recently received his Ph.D. degree in Animal Breeding at Oklahoma State University.

Robert S. Temple has been appointed Assistant Professor of Animal Husbandry at Louisiana State University, succeeding Dr. R. A. Damon who is now with Biometrical Services, ARS, USDA. Dr. Temple holds a Ph.D. in Animal Breeding from Iowa State College.

Robert C. deBaca, who recently received his Ph.D. degree in Animal Genetics at Oregon State College, has accepted a position as Extension Specialist in Animal Husbandry with the Iowa Agricultural Extension Service.

Charles W. Foley has been appointed Extension Animal Husbandman, Indiana Agricultural Extension Service, Lafayette, June 1, 1959. He received his B.S. and M.S. degrees from Missouri University.

Earl J. Peace, appointed Extension Dairy and Swine Specialist, Bozeman, Montana, July 1, 1959. He is a native of Montana and received his B.S. and M.S. degrees at Montana State College. His subject matter responsibilities will include swine in addition to dairy production and marketing.

Randall R. Reed, appointed Extension Meats Specialist, Columbus, Ohio, July 1, 1959. He is a native of West Virginia, and received his B.S. and M.S. degrees at West Virginia University.

John H. Carter, Jr., appointed Assistant Extension Animal Husbandman, June 16, 1959, with headquarters at Suffolk, Virginia. He received his B.S. and M.S. degrees at VPI.

Emmit H. Haynes, Extension Animal Husbandman, Iowa, Agricultural Extension Services, Ames, resigned June 30, 1959.

Hubert S. Patton, Arkansas Extension Animal Husbandman, resigned June 30, 1959.

George Thrasher, Indiana Extension Animal Husbandman, resigned July 31, 1959.

A. O. Jacobs, Montana Extension Dairy and Swine Specialist, resigned June 30, 1959.

O. Wayne Robison has joined the Animal Breeding Section of the Department of Animal Industry at North Carolina State College. His research responsibilities will be in the area of swine breeding. Dr. Robison is a native of Oklahoma and recently completed his graduate training at the University of Wisconsin.

H. L. Self, formerly of the Animal Husbandry Department at the University of Wisconsin, has accepted a position as Associate Professor of Animal Husbandry at Iowa State University. This position entails both responsibility of the agricultural experiment station and the cooperative agricultural extension service.

James W. Cobble, head of the Department of Animal and Dairy Husbandry, University of Rhode Island, has been appointed Associate Dean of the College of Agriculture and Associate Director of the Agricultural Experiment Station. Dr. Cobble will fill the position left vacant July 1 when W. H. Wiley became Dean. Dr. Cobble's three degrees are from the University of Missouri.

T. J. Cunha of the University of Florida spent the month of October advising and consulting the Central University of Venezuela at Caracus and Maracaya on their livestock program. His trip was sponsored by the Creole Oil Corporation of Venezuela and the Central University.

The National Science Foundation will award grants to defray partial travel expenses for a limited number of U. S. scientists who wish to participate in the Eighth International Grassland Congress. This Congress is to be held in Reading, England, July 11–21, 1960. Application blanks may be obtained from the National Science Foundation, Washington 25, D. C. *Completed* application forms must be submitted by February 1, 1960.

# SUBJECT INDEX FOR VOLUME 18, 1959

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